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THE

AMERICAN SYSTEM OF DENTISTRY.

IN TREATISES BY VARIOUS AUTHORS.

EDITED BY

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VOLUME III.

ANÆSTHESIA AND ANÆSTHETICS.—PHYSIOLOGY OF DIGESTION, VOICE, AND SPEECH.—ASSOCIATE DENTAL AND ORAL PATHOLOGY. —ORAL SURGERY.—ERUPTION OF THE TEETH.— MATERIA MEDICA AND THERAPEUTICS.— METALLURGY.—JURISPRUDENCE.

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PART I.

ANÆSTHESIA AND ANÆSTHETICS.

ANÆSTHESIA AND ANÆSTHETICS.

By WILBUR F. LITCH, M. D., D. D. S.

History.

The use of the term "anæsthesia" as designating the state of unconsciousness produced by the inhalation of volatile narcotic agents was first suggested by Oliver Wendell Holmes,[1] and, notwithstanding its inapplicability from the strictly etymological standpoint, and although terms more precise in their significance have since then been proposed—such as *nodynia*, favored by Sir James Y. Simpson, who has expressed regret that he did not adopt it, or *analgesia*, preferred by Prof. Roberts Bartholow, each word signifying loss of consciousness of, or loss of sensibility to, pain—the term "anæsthesia" has become firmly fixed in usage, and is to-day "repeated by the tongues of every civilized nation of mankind."

Although anæsthesia as now practised in surgical operations is of very recent origin, methods for producing insensibility to pain were not unknown to earlier civilizations. Whatever knowledge of pain-obtunding processes the ancient Greeks and Romans possessed was probably chiefly derived from Egyptian sources. Homer in the following passage ascribes such an origin to the draught which Helen gave to Menelaus and his guests:

"Then Helen, daughter of Zeus, turned to new thoughts. Presently she cast a drug into the wine whereof they drank—a drug to lull all pain and anger and bring forgetfulness of every sorrow. Whoso should drink a draught thereof when it is mingled in a bowl, on that day he would let no tear fall down his cheeks, not though his mother and his father died, not though men slew his brother or dear son with the sword before his face and his own eyes beheld it. Medicine of such virtue and so helpful had the daughter of Zeus, which Polydamnia, the wife of Thon, had given her, a woman of Egypt, where

[1] In a letter to Dr. Morton, dated Boston, Nov. 21, 1846, in which he says, "Everybody wants to have a hand in a great invention. All I will do is to give you a hint or two as to names—or the name—to be applied to the state produced and the agent.

"The state should, I think, be called '*anæsthesia*.' This signifies insensibility—more particularly (as used by Linnæus and Cullen) to objects of touch.

"The adjective will be '*anæsthetic*.' Thus we might say 'the state of anæsthesia' or 'the anæsthetic state.' The means employed would be 'the anti-æsthetic agent.' Perhaps the an-æsthetic agent, but this admits of question.

"I would have a name pretty soon, and consult some accomplished scholars, such as Professor Everett or Dr. Bigelow, Sr., before fixing upon the terms which *will be repeated by the tongues of every civilized nation of mankind*."

earth the grain-giver yields herbs in greatest plenty, many that are healing in the cup, and many baneful."[1]

The intoxicants or narcotic agents chiefly used by the Egyptians were opium, hyoscyamus, and Indian hemp, either singly or in combination. Prosper Alpinus, in his work on Egyptian medicine, clearly describes the intoxicating effects of the latter agent, and gives a formula for an electuary into which it enters in combination with opium, hyoscyamus-seeds, and other substances. The same author[2] states that the Egyptians used burning cotton and flax ("gossypii et lini") for the actual cautery, thereby producing a condition of stupor in which the suffering was much less intense than when the hot iron was used. It is very possible, as suggested by Dr. Sansom,[3] that instead of flax Indian hemp is here meant, and that the comparative insensibility to pain was due to the inhalation of its fumes. Color is lent to this suggestion by the fact, as stated by Herodotus in commenting upon the use of the vapor of hemp-seed in the vapor-baths of the Thracians, that the hemp which grew in Scythia was very like flax, and that "the Thracians make garments of it which closely resemble linen—so much so, indeed, that if a person has never seen hemp he is sure to think they are linen, and if he has, unless he is very experienced in such matters, he will not know of which material they are."[4]

According to the same author, intoxication by the fumes of burning hempseed was a common practice among the Massagetæ, a branch of the Scythian race, which race is believed by Niebuhr to be identical with the Mongols and Tartars. Of this practice Herodotus (book i. chap. 202) gives the following account: "Besides the trees whose fruit they gather for this purpose (food), they have also a tree which bears the strangest produce. When they are met together in companies they throw some of it in the fire around which they are sitting, and presently, by the mere smell of the fumes which it gives out in burning, they grow drunk, as the Greeks do with wine. More of the fruit is then thrown on the fire, and, their drunkenness increasing, they often jump up and begin to dance and sing. Such is the account which I have heard of this people."

Another branch of the Mongolian race, the Chinese, appears to have used hemp as a surgical anæsthetic as early as the second or third century of our era. In a paper on Chinese medicine, read by M. Stanislas Julien before the French Academy in the year 1849,[5] he alludes to an old Chinese medical work entitled *Koukin-i-tong*, in which is contained an account of this anæsthetic method as practised by one Hoa-tho. It is stated that "he gave the patient a preparation of hemp (*ma-yo*), probably by inhalation, and at the end of some instants he became as insensible as if he had been drunk or deprived of life. Then, according to the case, he made openings and incisions, performed amputations, and removed the cause of mischief: he then brought together the tissues

[1] *Odyssey*, lib. iv., translation of Butcher and Lang, London, 1879.
[2] Prosperi Alpini, *Medicina Ægyptorum*, lib. iii. c. xii. p. 213, ed. 1718.
[3] Sansom on *Chloroform*, pp. 17 and 18.
[4] Rawlinson's *Herodotus*, book iv. chap. 74.
[5] *Comptes rendus*, xxviii. p 195, 1849.

with sutures and applied liniments. After a certain number of days the patient found himself re-established, without having experienced the slightest pain during the operation."[1] The same drug is said to be used by the Hindoo suttee to deaden her sufferings when amidst the flames of the funeral pyre; and it is thought to have been an active ingredient in the "wine of the condemned" spoken of by the prophet Amos (Amos ii. 8) some seven hundred years before the Christian era, as well as in the draught given (with merciful design) to the Saviour upon the cross.

Mandragora, or mandrake, the root of Atropa mandragora, a plant indigenous to Southern Europe, appears to have been for many centuries in common use as an anæsthetic agent, although for a long period prior to the discovery of modern anæsthetics it had fallen into complete desuetude. The roots are described by modern observers as being "two or three feet long, conical, sometimes forked, an inch or more thick; in the fresh state fleshy, whitish, and of a heavy narcotic odor; in the dry state wrinkled, externally brown, but internally whitish."[2]

This root is described by Dioscorides, the Greek physician and botanist, whose celebrated treatise on the materia medica was written during the first century of our era, and an account of it is also given by Pliny in his *Natural History*. The forked character and general shape of the root give it some resemblance to the human form: this fact as well as its peculiar narcotic powers gave rise to many superstitious ideas and observances concerning it, there being a general belief that the plant shrieked aloud when torn from the earth, and that misfortunes were likely to follow those who gathered it unless certain precautions were observed. The following passage indicates that the superstition survived at least as late as the age of Shakespeare:

> "And shrieks like mandrakes torn out of the earth,
> That living mortals, hearing them, run mad."[3]

Pliny states that "persons when about to gather this plant take every precaution not to have the wind blowing in their face, and, after tracing three circles around it with a sword, turn toward the west and dig it up."

[1] Chinese surgeons still practise anæsthesia after the ancient methods. A recent traveller and most intelligent observer, Miss Isabella L. Bird, visited the Tung-Wang Hospital at Hong-Kong, China, and gives the following account of the anæsthetic processes as there conducted:

"No amputations are performed, but there are a good many other operations, such as the removal of cancers, tumors, etc. The doctors were quite willing to answer questions within a certain limit; but when I asked them about the composition and properties of their drugs, they became reticent at once and said that they were secrets. They do not use chloroform in operations, but they all asserted—and their assertions were corroborated by Mr. Ng Choy (governor of the hospital)—that they possess drugs which throw their patients into a profound sleep, during which the most severe operations can be painlessly performed. They asserted, further, that such patients an hour or two afterward are quite cheerful, and with neither headache nor vomiting! One of them showed me a bottle containing a dark-brown powder which he said produced this result, but he would not divulge the name of one of its constituents, saying that it is a secret taught him by his tutor, and that there are several formulas. It has a pungent and slightly aromatic taste" (*The Golden Chersonese and the Way Thither*, p. 111).

[2] *National Dispensatory*, Stillé and Maisch.

[3] *Romeo and Juliet*, iv. 3.

The same author describes the plant as consisting of "two varieties—the white mandragora, which is generally thought to be the male plant, and the black, which is considered to be the female. It has a leaf narrower than that of the lettuce, a hairy stem, and a double or triple root. . . . . Both kinds bear a fruit about the size of a hazelnut enclosing a seed resembling a pear in appearance. . . . . The juice is extracted both from the fruit and from the stalk, the top being first removed; also from the root, which is punctured for the purpose. . . . . Persons ignorant of its properties are apt to be struck dumb by the odor of this plant when in excess, and too strong a dose of the juice is productive of fatal effects. Administered in doses proportioned to the strength of the patient, this juice has a narcotic effect, a middling dose being one cyathus" (a little more than one ounce and a half).

"It is given, too, for injuries inflicted by serpents, *and before incisions and punctures are made in the body* in order to ensure insensibility to pain. Indeed, for this last purpose, with some persons, the odor of it is quite sufficient to induce sleep."[1]

It is of course evident that in this account Pliny has embodied much that is merely a record of current superstitions. This fault frequently detracts from the value of his observations, and casts doubt even upon what is authentic; especially is this true in the domain of medicine, with which as an art he had no practical acquaintance. Many of the statements in the passage just quoted are, however, sustained by the authority of Dioscorides, whose descriptions in this as in many other instances Pliny closely follows.

Dioscorides[2] describes "two genera—the black, supposed to be feminine, of which the leaves are longer and narrower than those of the lettuce," and "the white, said to be masculine," and states that the berries eaten by shepherds produce great stupidity and sleepiness; that the use of the drug promotes parturition ("*ciet atque partus*"), and that it is believed by some persons to stimulate amatory power ("*amatoriis efficax esse*"). Dioscorides further states that "some persons boil the root in wine down to a third part, and strain the decoction, of which they give a cyathus in cases of great distress or suffering in any part, as well as before cutting or burning, that pain may not be felt."

A wine made from the bark of the root is also described: "Three *minæ* (pounds) are thrown into a *cadus* (about eighteen gallons) of sweet wine, and of this three cyathi are given to those who are to undergo cutting or cauterization, as before stated."

Of another species of mandragora—which, Dioscorides states, is also called morion, and which, from the description he gives of the plant, is believed by many to be identical with the Atropa belladonna—it is narrated that "a drachm of it being drank at a draught, or being eaten in a cake or otherwise taken with food, causes infatuation and takes away the use of reason. The person, in the very attitude in which he ate the drug, falls into a deep sleep, and is not master of his senses for

[1] Pliny's *Natural History*, book xxv. chap. 94.

[2] *Pedani Dioscoridis Anazarbæi Medici Antiquissimi*, "De Mandragora," lib. iv. cap. lxxvi.

three or four hours, according to the amount given. Physicians also use this when cutting or burning is necessary."

Celsus, a Latin writer on medicine who is supposed to have lived in Rome during the first century, states, in treating "of the various forms of madness and their cure," that in cases of obstinate insomnia mandrake apples are put under the pillow of the patient.[1]

Apuleius Platonicus, a writer whose personality is somewhat obscure,[2] but who was the author of an extant Latin work on plants and their properties, says in regard to mandragora[3] that "if any one is to have a member mutilated, burnt, or sawn, let him drink half an ounce with wine, and so deeply shall he sleep that the member may be cut away without any pain or sensation."

Aëtius, the Greek physician, who lived probably about the end of the fifth or commencement of the sixth century, alludes to the soporific properties of the drug. He says[4] that "those who have drunk of the root become sluggish, languid, dejected, and cold, and fall into a heavy lethargic slumber, from which they are aroused with difficulty, and, being awakened, they quickly fall backward again asleep."

Paulus Ægineta, the Greek medical writer, who lived a century later than Aëtius, states[5] that "when mandragora has been drunk stupor immediately comes on, with loss of strength and a strong inclination to sleep, so that the affection differs in nothing from that which is called lethargy."

In the writings of the Middle Ages frequent allusions are made to anæsthetic preparations. Thus, Theodoric of Servia, who died in 1298, describes a "soporific confection" made after the formula of Dominus Hugo, as follows:[6] "Take of opium and of the juice of unripe mulberry, of hyoscyamus, of the juice of conium, of the juice of the leaves of mandragora, of the juice of wood-ivy, of the juice of the forest-mulberry, of the seeds of lettuce, of the seeds of burdock which has apples hard and round, and of the water hemlock, each an ounce. Mix all of these in a brazen vessel, and then place in it a new sponge. Let it all boil as long as the sun in the dog-days, until it is all consumed and boiled away in it [the sponge]. As often, moreover, as there is need place the same sponge in warm water for one hour, and then let it be applied to the nostrils until sleep seizes him who is to be incised, and in this state let the surgery be done. This being finished, in order that the

[1] Aur. Corn. Celsi, *De Medicina*, libri octo, Amstelædami, 1713, lib. iii. chap. xviii.

[2] Apuleius Platonicus—or, as he is sometimes called, Lucius Apuleius Barbarus—must not be confounded with the pagan philosopher Apuleius de Madaura, who lived about 150 A. D., and who was the author of the *Metamorphosis of The Golden Ass*, and other works: this mistake has been made by several authors, but the two writers were distinct personages, and what are now recognized as the extant works of Apuleius de Madaura do not contain the *De Herbarum Virtutibus* from which the passage quoted is taken, although it has incorrectly been placed in certain editions of his writings. Some authorities claim (see *Nouvelle Biographie générale*, Paris, 1857) that the name Apuleius attached to that work was a pseudonym, and that its real author was one Celsus, a Sicilian physician who lived during the second half of the fourth century, and who was the preceptor of Valens and Scribonius Largus.

[3] Apuleius Platonicus, *De Herbarum Virtutibus*, Basiliensi, 1528, cap. 131, line 22 *et seq.*

[4] Aëtii, *Medici*, Quartæ Sermo I. cap. lxviii.

[5] Lib. v. sect. xliv.

[6] Theodorici, *Ars Chirurgica*, lib. iv. cap. viii., "De somniferis distillationibus."

patient may be aroused place another sponge dipped in vinegar frequently to his nostrils."

Baptista Porta[1] quotes Dioscorides on the sleep-producing power of mandrake, and cites from Junius Frontinus an apocryphal account of a stratagem said to have been practised by Hannibal against certain warlike rebels in Africa—namely, that of mixing mandrake with wine, counterfeiting a flight, and leaving the wine in his camp to be consumed by the enemy, who, being soon overcome by its effects, were then easily put to the sword.

Porta also describes[2] how "a sleeping-apple is made of opium, mandrake, juice of hemlock, the seeds of henbane, and adding a little musk to gain an easier reception to the smeller: these, being made up into a ball as big as a man's hand can hold, and often smelt, do gently close the eyes and bind them with a deep sleep." He also states[3] that "out of many of the afore-named dormitive menstruis there may be extracted a quintessence which must be kept in leaden vessels very closely stopped, that it may not have the least vent, lest it should flie out. When you would use it uncover it, and hold it to a sleeping man's nostrils, whose breath will suck up this subtile essence, which will so besiege the castle of his senses that he will be overwhelmed with a most profound sleep, not to be shook off without much labor. After sleep no heaviness will remain in his head, nor any suspicion of art. These things are manifest to a wise Physitian, but to a wicked one obscure."

In quoting this passage, Dr. Silvester states (*Administration of Anæsthetics in Former Times*) that "there is much reason to believe that alcohol and ether were in the hands of the initiated, and employed in the extraction or solution of the active qualities of plants and herbs;" and in support of this opinion a formula for an *aqua ardens* (from Albertus Magnus, *Mirab. Mundi*, p. 216) is referred to, its chief ingredients being "strong, old, dark-colored wine, quicklime, and common salt distilled into an alembic and kept in a glass vessel." Certainly from the distillation of such a mixture it is very possible that an ether or chloroform might be formed.

Mandrake is also described by Bullein, an early English writer, who states[4] that "this herbe is cold in the third degree, and hath virtue to cause deep sleep: the strength is in the apple and in the rind of the root. The remnant—that is, the leaves and inward parts of the root—is but weak, sayeth Galen. . . . . The juice of this herb, pressed forth and kept in a close earthen vessel according to arte, bringeth sleepe, and casteth men into a trans or a deepe terrible dreame, until he be cut of the stone."

Dr. Madden[5] quotes at second hand from Turner's *Herball*, published in 1551, an account of a wine "of the roots of the mandrake, to be given to persons who had to be cut, scarred, or burned, and they shall feel no pain, but they shall fall into forgetfulness and sleepy drowsiness."

[1] *Natural Magic*, by John Baptista Porta, a Neapolitaine, in twenty books, London, 1658, lib. ix.

[2] *Ibid.*

[3] *Ibid.*

[4] Bullein's *Bulwarke of Defence against all Sickness, Soarness, and Wounds that doe dayly assault Mankinde*, London, 1579, p. 44.

[5] *Dublin Journ. Med. Science*, vol. lix. pp. 32–38.

Not only mandragora, but other narcotics, appear to have been used for anæsthetic purposes. Dr. Rice[1] quotes J. Canape (or Canappe), physician to Francis I., as speaking of the procedure of Theodoric and others, and referring to the dangers of the internal administration of narcotics, as follows: "*Les autres donnent* opium à boire, et font mal, spécialement s'il est jeune, et l'aperçoivent; car cest avec une grande bataille de vertu animale et naturelle. J'ai ouï qu'ils encourent manie, et par consequent, la mort."[2]

There is abundant evidence, too, that as late as the sixteenth century stupefying agents were frequently given to criminals about to be submitted to torture, for the purpose of relieving their sufferings. Sir James Y. Simpson[3] quotes the following:[4] "As to their artifices not to feel the pain of the rack, I saw in the first year of my reception at the bar of Beaujolais, which was in the year 1588, that one of four thieves who were prisoners, the chief, named Grand François, a man of gigantic stature, was put to the rack, fell asleep, and the toes were torn from both his feet without his manifesting any signs of pain. One of his companions observed that he had eaten soap, which stupefied the nerves. The remedy to the artifice is to give wine, which being brought and drunk, he then said he was dead, and without any further torture freely confessed an infinite number of murders and robberies, to atone for which he and his companions were broken in the wheel by sentence of Master Thomassot, provost of the mareschals in Beaujolais."

The frequent allusions to the virtues of mandragora in popular literature, even as late as the time of Shakespeare, seem to indicate a widespread belief in its anæsthetic power. Thus in the *Metamorphosis* of Apuleius,[5] a physician who had been solicited to furnish poison for a criminal purpose is made to say, "I gave him not poison, but the somniferous mandragora, famous for the torpor which it occasions, and which produces a sleep most similar to death;" the result of this substitution being that the victim of the intended crime was rescued from the grave in which he had been placed just as the effects of the poison had begun to be dissipated.

It was doubtless a similar potion which Shakespeare had in mind as causing Juliet's death-like slumber in the tomb of the Capulets, for his dramatic works contain several allusions to the drug and its soporific powers. Cleopatra exclaims,

> "Give me to drink mandragora, ...
> That I might sleep out this great gap of time
> My Antony is away."[6]

And Iago soliloquizes:

> "Not poppy nor mandragora,
> Nor all the drowsy syrups of the world,
> Shall ever medicine thee to that sweet sleep
> Which thou owedst yesterday."[7]

[1] *Trials of a Public Benefactor*, p. 75.
[2] *Les Guidon pour les Barbiers et les Chirurgiens*, Lyons, 1538.
[3] *Anæsthesia*, p. 7.
[4] *Le Procès criminal*, by Claude Lebrun de la Rochette, book ii. p. 144.
[5] Apulei Madaurensis Platonici, *Metamorphoseon*, sive Lucus Asini, Francofurti, anno MDCXXI., lib. x. chap. xxxv.
[6] *Ant. and Cleo.*, i. 5.
[7] *Othello*, iii. 3.

The tragedy of *Women, beware of Women*, written by Middleton and published about 1657, contained the following allusion :

> " *Hippolito.* Yes, my lord,
> I make no doubt, as I shall take the course
> Which she shall never know till it be acted,
> And when she wakes to honor, then she'll thank me for it.
> I'll imitate the pities of old surgeons
> To this lost limb, who, ere they show their art,
> Cast one asleep, then cut the diseas'd part;
> So out of love to her I pity most
> She shall not feel him going till he's lost."

This figure was made use of nearly a century earlier by Du Bartas in his poetical account of the creation of Eve from a rib taken from the side of Adam [1] during sleep :

> " Even as a surgeon, minded off to cut
> Some cureless limb, before in use he put
> His violent Engins on the vicious member,
> Bringeth his Patient in a sense-less slumber,
> And grief-less then (guided by use and art),
> To save the whole, sawes off the infected part :
> So God empal'd our Gransire's lively look,
> Through all his bones a deadly chillness strook,
> Siel'd-up his sparkling eye with Iron bands,
> Led down his feet (almost) to Lethe's Sands.
> In brief, so nummed his Soules and Body's sense
> That (without pain) opening his side, from thence
> He tooke a rib, which rarely he refin'd,
> And thereof made the mother of mankind."

The following references to somniferous drugs occur in the *Decameron* of Boccaccio, written during the fourteenth century : " He (the Abbot) was never without a certain kind of drug, which, being beaten into powder, would work so powerfully upon the brain, and all the other vital senses, as to entrance them with a deadly sleep, and deprive them of all motion, either in the pulse, or any other part else, even as if the body were dead indeed ; in which operation it would so hold and continue, according to the quantity given and drunk, as it pleased the Abbot to order the matter. This powder or drug was sent him by a great Prince of the East."

And in another of the same series of novels the following is related : " It occurred that the surgeon had in hand a patient, one of whose limbs was diseased, and knowing whence the evil proceeded, told the man's friends that if a rotten bone in the leg was not removed it would be necessary to cut off the limb or the patient would die, but by removing the bone it might be cured : however, he would not undertake the operation unless the patient were given up as dead. To this the family agreed. The surgeon, thinking that if the patient were not sent to sleep he would be unable to bear the pain, and would not permit the operation, deferred performing it till the following morning ; and distilled in the morning a water of a certain composition of his own, which, when the patient had drunk of it, would keep him asleep as long as the operation might last."

[1] *The Works of William de Sallust du Bartas*, translated by Joshua Sylvester, London, 1595.

Dr. Silvester quotes[1] the following from a translation of A. G. Meissner's *Skizzen* (or *Sketches*), a German work published in Carlsruhe A. D. 1782: "Augustus, king of Poland and elector of Saxony, suffered from a wound in his foot which threatened to mortify. The court medical men were opposed to the operation of amputation, but during sleep, induced by a certain potion surreptitiously administered, his favorite surgeon, Weiss, a pupil of Petit of Paris, cut off the decaying parts. The regal patient was disturbed by the proceeding, and inquired what was being done, but on receiving a soothing answer he again fell asleep, and did not discover till the following morning, after his usual examination, that the operation of amputation had really been performed."

Pliny has indicated[2] a method for producing local anæsthesia. He says: "There is also a marble known as 'memphites,' from the place (Memphis in Egypt) where it is found, and of a nature somewhat analogous to the precious stones. For medicinal purposes it is triturated and applied in the form of a liniment with vinegar to such parts of the body as require cauterizing or incision, the flesh becoming quite benumbed, and thereby rendered insensible to pain."

The local anæsthesia (if any) thus obtained was probably due to the effect of the carbonic acid gas evolved during the reaction between the acetic acid and the calcium carbonate.

A more apocryphal statement concerning this same stone is made by the celebrated philosopher and theologian, Albertus Magnus, sometimes called "Doctor Universalis," who was born about 1200 A. D. He says:[3] "To prevent any one from feeling pain or torture take of the stone which is called memphites, from the city which is called Memphis, and which, according to Aaron and Hermes, is of such virtue that if it be pulverized and mixed with water, and given to drink to him who is about to be cauterized or who is about to suffer any other kind of pain, he, so much does this drink induce insensibility, will not feel any pain whatever."

This is doubtless purely fabulous, and the efficacy of the formula for a soporific confection given by Theodoric (see p. 23) may be received with almost equal doubt.

In this connection it is perhaps worthy of note that Dr. Rice quotes M. Dauriol, "a French physician residing in the neighborhood of Toulouse," as asserting in the *Journal de Médecine et de Chirurgie de Toulouse* (January, 1847) "that in 1832 he followed the directions given by Theodoric, and operated several times (five) with success." But, so easy is self-deception in medical practice, this unsupported statement can hardly be accepted as conclusive. As has been pointed out by Snow, the active principle of the plants employed in the formula of Theodoric are not sufficiently volatile in their character to be given off at the temperature of the boiling water in which it is directed that the sponge shall be immersed before placing it to the nostrils of the patient, and the only possibility of narcosis resulting from such a procedure was from the accidental intrusion of the liquid contents of the sponge into his mouth or nostrils.

[1] *Medical Gazette*, vol. vi. p. 513. [2] *Natural History*, book xxxvi. chap. ii.
[3] Alberti Magni, *De Secretis*, etc., MDCXXXVII. lib. ii., "De Virtutibus Lapidum"

A greater degree of probability attaches to certain of the statements concerning mandragora which have been quoted in preceding pages. Indeed, the experiments made with this drug by Dr. Benjamin W. Richardson[1] fully establish the fact that, internally administered, it possesses a high degree of narcotic power. Dr. Richardson found the active principle of the root to be insoluble in absolute alcohol, but, like atropia, most soluble in water; he therefore made a weak tincture, using only one part of alcohol to five parts of water, which was much after the manner of the ancients, whose most potent preparations of the drug were either decoctions or infusions in wine. The tincture thus made he "found to possess the most active properties—properties faithfully represented by the ancients in their observations."

He found that whether administered by the mouth or by subcutaneous injection the active principle is absorbed with great rapidity: the effects produced are those of narcotism—dilatation of the pupil, paralysis of motion and sensation, excitement during the stage of recovery if the dose be not fatal, and sleep and paralysis if the dose be too potent; "that given to human subjects in doses not sufficient to produce actual narcotism, the symptoms produced are desire for sleep, a sense of fulness in the vessels of the head, a peculiarly enlarged and confused vision. . . . . These symptoms are not actually removed for two days, and they leave a lingering uneasiness and a coldness still longer," thus showing a remarkable slowness in the elimination of the poison from the system, and in a measure justifying the statements made by ancient writers concerning the long duration of its influence.

In concluding the account of his investigations Dr. Richardson says: "There are as yet many new facts to be learned respecting this old medicine and poison, mandragora. We have still to separate its active principle and to determine the relation of that body to atropine. Two facts are, however, now certain in regard to it: that many of the old and discredited statements on the influence of mandragora are perfectly credible. The physiological fact is, that the active principle of mandrake is a narcotic, possessing, when carried to an undue extent, poisonous properties, and that its action is to paralyze the nervous centres that exert a controlling or resistant influence on the minute vascular circulation."

These more recent researches of Dr. Richardson confirm the opinion expressed nearly thirty years earlier (1847) by Dr. Francis Adams in his commentary on, and translation of, Paulus Ægineta (vol. iii. p. 241), that "although it [mandragora] has now disappeared from our dispensatories, we see no good reason why its well-regulated use might not be revived." But, as has already been intimated, surgery during the period immediately preceding the discovery of modern anæsthesia had almost ceased to look or to hope for the merciful ministrations of a pain-obtunding agent; only now and then was a hint such as this given that it was still thought of as a possibility.

An earlier and more significant observation was made in the last years of the last century by Sir Humphry Davy, who in the year 1798, he being not then twenty years of age, was selected for the position of

[1] *British and Foreign Medico-Chirurgical Review*, Jan., 1873.

superintendent of a pneumatic institution established by Dr. Thomas Beddoes at Clifton in the suburbs of Bristol, England, for the purpose of ascertaining by experiment the medicinal virtues of certain of the newly-discovered gases. Although so young, Davy was in the highest degree qualified for his task. He had since 1795 been regularly apprenticed to a surgeon and apothecary, and had entered with enthusiasm upon his medical studies, especially the branches of natural philosophy and chemistry. The time, too, was peculiarly propitious for original investigation in the domain of pneumatic chemistry. Black had proved the existence of a gaseous substance other than atmospheric air; Priestley had discovered oxygen gas and nitrous oxide; and Lavoisier had shown that oxygen supported flame and respiration; hydrogen had been examined in the pure state by Cavendish, and the foundation of modern chemistry laid by his discovery of the formation of water by the union of the two gases. These and the rapidly-succeeding isolation of other gases, such as nitrogen by Rutherford and chlorine by Scheele, could not fail to excite in the minds of men the highest degree of interest and expectancy. Ignorant of the true possibilities and limitations of the newly-discovered substances, the hope was entertained that they would exercise a vast and direct influence in ameliorating the miseries of mankind through the cure of disease. This thought it was which led to the establishment of Dr. Beddoes's pneumatic institution. The idea, however, proved illusory: no very great amount of success was ever attained, although at one time Davy wrote hopefully about it, saying, "Our patients are becoming daily more numerous, and our institution, in spite of the political odium attached to its founder, is respected even in the trading city of Bristol. I shall soon send you an account of the success we have had in curing some of the most obstinate diseases by new remedies. The nitrous oxide we have found very beneficial in many cases of palsy."[1]

Davy also records in his *Researches concerning Nitrous Oxide*, first published in 1800, instances in which headache was cured by this agent, and gives the following illustration of "the power of the immediate operation of the gas in removing intense physical pain:" "In cutting one of the unlucky teeth called dentes sapientiæ I experienced an extensive inflammation of the gum, accompanied with great pain, which equally destroyed the power of repose and of consistent action. On the day when the inflammation was most troublesome I breathed three large doses of nitrous oxide. The pain always diminished after the first four or five inspirations; the thrilling came on as usual, and uneasiness was for a few minutes swallowed up in pleasure. As the former state of mind, however, returned, the state of the organ returned with it; and I once imagined that the pain was more severe after the experiment than before."[2]

Much more significant is the following suggestion: "As nitrous oxide in its extensive operation appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in

[1] *Memoirs of the Life of Sir Humphry Davy*, p. 81.

[2] *Researches, Chemical and Philosophical, chiefly concerning Nitrous Oxide, or Dephlogisticated Nitrous Air, and its Respiration*, by Sir Humphry Davy, Bart., p. 276.

which no great effusion of blood takes place."[1] This suggestion, so illustrative of the keen insight and marvellous prevision of this great master of inductive chemical philosophy, was unheeded, and Davy's connection with the pneumatic institution being soon after terminated by his acceptance of the professorship of chemistry in the Royal Institution of Great Britain, his genius was diverted into channels of chemical research less associated with medical or surgical practice, and so he failed to pursue a line of investigation he was so pre-eminently qualified to follow, and the continued prosecution of which would doubtless have resulted in the speedy discovery of a practical anæsthetic process.

In 1828, Mr. Hickman, a London surgeon, wrote a letter to Charles X., king of France, in which he asserted "that he had discovered the means of performing the most troublesome and dangerous operations without pain. The method consisted in producing temporary insensibility by the methodical introduction of certain gases in the lungs. Mr. Hickman had made numerous experiments on animals, and was desirous of obtaining the co-operation of the leading physicians and surgeons of Paris in order to make the same experiments upon the human subject."[2] This letter was reported to the French Academy by M. Gérardin, but as it contained no specific statement concerning the nature of the gases employed, little attention was given to it either in France or England, and, Mr. Hickman dying soon after, his secret died with him. By some it has been conjectured that his anæsthetic agent was diluted carbon dioxide.

As illustrative of the difficulties of surgical practice before the discovery of anæsthesia, and of the extreme measures which were sometimes resorted to, the following case reported[3] by "James Wardrop, Esq., Surgeon Extraordinary to the Prince Regent," is of great interest. Mr. Wardrop alludes to the difficulties attending operations upon young children where "mechanical neatness or dexterity is necessary," he recommending in the latter class of cases "enclosing all the body except the part to be operated upon either in a bag or wooden box." He also states that it was not uncommon to find adults who could not summon courage enough to submit to the knife, and says that "examples are by no means rare where persons have suffered severe distress, or even died, from disease which they were convinced might have been relieved by a surgical operation."

He then describes the case of a young woman "of a robust form" who "had a tumor on the orbitar (*sic*) plate of the left frontal bone," and says: "Though she had come from a distance determined to get the disease removed by an operation if it was considered advisable, yet when the scalpel touched the integuments she made a violent resistance. A second attempt was made, having previously secured her on a table with numerous assistants, but such was the force and exertion she made to extricate herself whenever the operation was about to be begun that

[1] *Researches, Chemical and Philosophical, etc.*, p. 329.
[2] *Archives générales*, vol. xviii., First Series, p. 453, or *Medical Times* of London, vol. xvi. p. 444.
[3] *Medico-Chirurgical Transactions*, 1819, pp. 273–277.

every hope of success was abandoned. As the only resource it then occurred to me that if she would allow herself to be bled to a state of deliquium the tumor might be extirpated while she remained insensible.

"After a few days she submitted to this measure, and a large vein was freely opened while she sat in the erect posture in a very warm room, in which there were seven people, with the doors and windows kept shut to hasten her fainting. No less than fifty ounces of blood were drawn before she fainted, and then a complete state of syncope came on, which lasted a sufficient time to allow the tumor to be removed. . . . . When the fainting went off she would not believe that the operation had been performed until she examined her face in a glass. . . . . She rapidly recovered her strength without in any way appearing to have suffered from the loss of blood."

Mr. Wardrop did not at all recommend this method of practice for general adoption, but states that he was emboldened to adopt it "from having almost universally observed that those patients recovered from operations best who lost the greatest amount of blood—a fact strikingly illustrated in the battle of Waterloo, when it was found that the wounded who were left in the field, and not taken into hospitals till the fourth or fifth day after the battle, recovered much sooner than those who were immediately attended to." This difference, according to Mr. Wardrop, "could only be accounted for by the bleeding from the wounds being so extensive as to produce syncope, thus preventing inflammation and fever." Modern pathology, it is hardly necessary to remark, would certainly attach to it quite a different significance.

That one of the most marked physiological effects of alcohol narcosis is a more or less complete anæsthesia has long been a generally recognized fact, and the annals of surgery furnish many cases in which painless operations have been performed upon patients while under the influence of this agent.

Richerand[1] remarks that it is well known how easy it is to operate (for luxations) upon drunken people, and recommends the use of wine, "pousseé jusqu'a l'ivresse," to produce muscular relaxation.

Lallemand and Perrin[2] quote Percy as relating that certain bone-setters administered warm wine to their patients for the purpose of obtaining in the sleep of drunkenness insensibility and muscular paralysis, and that he had seen reduced by this means a luxation of the shoulder in which several attempts without the wine had failed.

The case of Deneux is also quoted, in which he states that a woman "upon the point of being confined was carried to the Hôtel Dieu d'Amiens in a comatose state caused by the abuse of alcoholic drinks, she having been in this state at the commencement of her labor. She was delivered naturally during this condition of drunkenness, and her sleep of ebriety continued for a considerable time after her deliverance. Upon awakening she was greatly astonished to see her accouchement ter-

[1] *Nosographie chirurgicale ou Nouveaux Élémens de Pathologie*, tome troisième, pp. 192–194.

[2] *Du Rôle de l'Alcool et des Anesthésiques dans l'Organism*, par Ludger Lallemand et Maurice Perrin, Paris, 1860, p. 13.

minated, and felicitated herself upon having found so happy a method, and avowed her determination to avail herself of it upon the first occasion."

Lallemand and Perrin also refer to the case of Blandin,[1] in which he amputated the thigh of a man found dead drunk in the public highway, the man not experiencing the slightest sensation during the operation.

Several cases equally remarkable are referred to by a writer on "Painless Operations in Surgery" in the *North British Review*,[2] one case being that of an Irishman "part of whose face was eaten by a pig while he was lying dead drunk on the ground," and another, that mentioned by Professor Quain, "where a man in a state of intoxication fell from a coach, and had a shattered leg amputated; on coming to himself he affirmed that he knew nothing either of the accident or the operation." The above writer also quotes Mr. Lawrence as saying that "many years ago a middle-aged woman was brought into St. Bartholomew's drunk with a compound fracture and other serious injury of the leg requiring amputation. Having reflected on the circumstances, I could see no reason why the state of intoxication should prevent the performance of an operation absolutely necessary, and I accordingly removed the limb at once above the knee in the ward. The gentlemen present and myself were perfectly satisfied that the patient was unconscious of the proceeding, though, being subsequently jeered on the subject by some of her fellow-patients, she contended that she knew what was done at the time, but did not feel pain."

The claims of mesmerism, or so-called "animal magnetism," hardly demand extended consideration here, although at one time the subject excited widespread interest in all civilized countries, and many remarkable cases are on record in which grave surgical operations were, it is claimed, painlessly performed upon individuals who had been thrown into the "magnetic sleep." Whether these cases were authentic or whether made up of delusion on the one hand and deception on the other, it is not necessary here to discuss. The burden of evidence would seem to indicate that in certain weak and susceptible temperaments there may be, under the impulsion of a stronger will, a state of hypnotism produced in which consciousness and sensation are abolished—a condition closely allied to those peculiar psychological phenomena so frequently manifested in hysteria or in certain states of religious frenzy.

Dr. Rice[3] states that in the year 1849, during a residence in Calcutta, he paid a visit to the public hospitals of the city, where some experiments with animal magnetism were then being made, and that "the trials of the power made there were even carried so far as to have the patients thrown into the insensible state by their merely drinking water which had been magnetized, and which was given them to drink before the operation without their being aware of its character. Some certainly very remarkable results were witnessed. Patients were operated upon without their evidencing pain who, it was averred, were acted upon by no agent but mesmerism. But the effects were by no means certain or uniform: some were not affected at all or were affected

[1] Reported in the *Bullétin de l'Académie de Médecine*, Paris, 1847, t. xii. p. 517.
[2] Vol. vii. p. 103, May, 1847.
[3] *Trials of a Public Benefactor*, p. 79.

in a different manner from what was intended. If, however, there is 'something in it,' the reason is plain why its use could never be introduced into surgical practice. It requires a long time and many continued attempts before the patient can be thrown into a perfect state of general or local insensibility. But few persons are in any degree sensible to the influence, while the real subject who can be thrown into the state of trance is as rare as a white blackbird."

Various attempts to not entirely abolish, but to obtund, sensation have from time to time been made. The method suggested by Mr. J. Moore of London was the compression of the principal nerves of a limb above the point to be operated upon, this compression to be effected by a suitably-shaped instrument with pads and a screw. This method was tested in St. George's Hospital, London, by Sir John Hunter, the case being one of amputation in the lower third of the thigh. The suffering was thought to have been considerably mitigated.

Velpeau states[1] that the practice "extolled by Juvet," of "applying a strap tied tight above the place where the parts were to be divided . . . . is not to be despised in some cases." He also alludes to the practice recommended by some writers of not using the bistoury until they have dipped it into hot oil or hot water to bring it to the temperature of the body or above it, and states that he cannot deny that it gives less pain, but concludes that the difference is not sufficiently important to warrant the introduction of so troublesome a procedure into general practice.

The administration of moderate doses of opium previous to surgical operations, with a view to blunting nervous sensibility, was a plan which found great favor with many. Prof. S. D. Gross[2] says: "I was myself in the habit of employing it for many years in almost every case that fell into my hands previously to the discovery of anæsthetics: I generally preferred morphia to laudanum or opium in substance, and always gave it in full doses, either alone or, when the patient was strong and plethoric, combined with a moderate quantity of tartrate of antimony and potassium, with a view of inducing a greater degree of relaxation and insensibility. I became very fond of the practice, and never, so far as I could determine, experienced any bad effects from it: on the contrary, I know that it was commonly productive of great benefit, not only blunting sensibility, but preventing shock and, consequently, severe reaction." Others, however, claimed that the practice was objectionable, inasmuch as the use of opium impeded a healthy reaction from shock.

The literature of anæsthesia thus far recorded clearly demonstrates the fact that the surgeons of the ancient, mediæval, and modern world were not oblivious to the desirableness of abolishing—or at least obtunding —the pain incident to all surgical operations. Why, the need being so great, a practicable anæsthetic process should not have been discovered and universally adopted at a much earlier period than it was might well be made a subject for curious, if not profitable, speculation.

It is, of course, true that to a greater or less degree all scientific progress is correlated, and that no great thought can be born out of due

[1] *New Elements of Operative Surgery*, vol. i. pp. 22–24.
[2] *A System of Surgery*, vol. i. p. 547.

time. Still, with the discovery of modern anæsthesia, as with the greater number of discoveries in practical medicine or surgery, the existence or nature of these correlations is not so evident. It can hardly be said that the undeveloped state of chemical and physiological knowledge prevented an earlier discovery, because, as a rule, discoveries relating to the powers and properties of drugs are empirical in their character, and, in the past at least, have generally been entirely disconnected from any scientific apprehension of their ultimate chemical and physiological effects. In this regard physiology may be said to owe more to modern anæsthesia than it to physiology.

While it is true that anæsthesia by the inhalation of sulphuric ether could not have been possible before the time of Valerius Cordus—if he be accepted as among the earliest to possess a knowledge of its genesis and properties—or that anæsthesia by nitrous oxide gas could not have been practised before its discovery by Priestley, still, putting aside the whole group of vegetable narcotics, man has from almost the earliest period in his history possessed an agent not so convenient as the more volatile substances now employed, but far safer than many of them, and one with the effects of which in abolishing consciousness and sensation but few races or peoples are not practically familiar. So great are the advantages, direct as well as indirect, arising from anæsthesia in surgery that it cannot be doubted that were other agents lacking alcohol would now be generally resorted to, as, indeed, as a matter of preference, it of late years has been by one American practitioner. And yet hardly more than a decade before the discovery of modern anæsthesia, advanced as chemistry and physiology then were, all search for an anæsthetic agent had, with here and there an exception, been practically abandoned by the medical profession, and the distinguished French surgeon Velpeau, after alluding to the history of the subject, used the following emphatic language: "To avoid pain under incisions is a chimera which is no longer pursued by any one. A cutting instrument and pain in operative surgery are two words which never present themselves separately to the mind of the patient, and of which he must of necessity admit the inevitable association."[1]

In view of this utterance it is of interest to read that at a meeting of the French Académie des Sciences, held Monday, January 18, 1847, the newly-discovered anæsthetic powers of sulphuric ether were under discussion, and that M. Velpeau gave an account of his successes, partial and complete, of his difficulties, etc., and in a foot-note to the published proceedings states: "This very morning (Friday, 22d) I have removed an enormous cancer from the thigh of a man who had not the slightest perception of the operation."[2] So radical a change of opinion was due to the great discovery whose history will now be reviewed.

Discovery of Modern Anæsthesia.

On the evening of the 10th day of December, 1844, an audience had gathered in Union Hall, in the city of Hartford, to witness demonstra-

[1] *Nouveaux Élémens de Médecine opératoire*, p. 10, Bruxelles, 1832.
[2] *Compte rendus*, séance du Lundi, 18 Janvier, 1847, p. 74.

tions in chemistry made by one G. Q. Colton, an itinerant lecturer on that science. Among other experiments an exhibition was made of the intoxicating properties of nitrous oxide gas, inhaled, after the manner of that day, from a bag of oiled silk or other air-tight material. Such exhibitions were then common, and as only stimulating doses were administered audiences were frequently amused by the grotesque and often violent antics of the subjects of the experiment. After the lecture in question several gentlemen of the audience, being interested in the subject, requested that a private exhibition be given them on the following morning, December 11, 1844.

Among those present as spectators the next day was Horace Wells, a practising dentist of Hartford, and also Samuel A. Cooley, a druggist and a citizen of the same town. Mr. Cooley inhaled a portion of the gas with a view to ascertaining its effects upon his own person, and while under its influence ran against and overthrew some of the benches in the hall, thereby producing, unconsciously to himself, several severe abrasions upon his knees. After recovering from the effects of the nitrous oxide his attention was called by the spectators to the apparent violence inflicted upon himself, and upon exposing his knees to those present it was found that the skin was quite badly bruised and broken.

Dr. Wells was an interested observer of this fact, and, according to the testimony of Mr. Cooley, remarked "that he believed that a person could have a tooth extracted while under its influence and not experience any pain." Dr. Wells, having a troublesome wisdom tooth, proposed that a bag be filled with the gas and that the experiment be at once tried in his office. A number of those present, including Colton, Wells, and Cooley, proceeded thither. What occurred there is perhaps best given in the language of Dr. J. M. Riggs, dentist, whose office was in a room adjoining that of Dr. Wells:

"Dr. Wells, a few minutes after I went in and after conversation, took a seat in the operating-chair. I examined the tooth to be extracted with a glass, as I usually do. Wells took the bag of gas from Mr. Colton and sat with it in his lap, and I stood by his side; Wells then breathed the gas until he was much affected by it; his head dropped back. I put my hand to his chin; he opened his mouth, and I extracted the tooth; his mouth still remained open some time. I held up the tooth in the instrument that the others might see it, they standing partially back of the screen and looking on. Dr. Wells soon recovered from the influence of the gas so as to know what he was about—discharged the blood from his mouth, swung his hand and said, 'A new era in tooth-pulling!' He likewise said it did not hurt him at all. We were all much elated, and conversed about it for an hour after."

The practicability of the use of this gas as an anæsthetic in surgical operations, first suggested by Sir Humphry Davy nearly half a century before, was at last verified. There is no evidence, and but little probability, that Wells was acquainted with Davy's observation, and the honor of the first discovery and application of a safe and efficient anæsthetic agent undoubtedly belongs to him.

During the next few weeks nitrous oxide gas was successfully administered by Dr. Wells to several of his patients, and, encouraged by these

results, he in the winter of 1844–45 went to Boston—where he had formerly practised dentistry, and which was then, as it is now, the centre of medical education in the New England States—for the purpose of making his discovery known to the medical faculty, and of securing a trial of his invention in surgical operations other than the extraction of teeth. In Boston he called upon Dr. William T. G. Morton, a former pupil, who in 1842 had been associated with him in the practice of dentistry in that city, and asked his assistance in bringing his invention before the medical faculty.

Among those to whom he was introduced by Morton were Dr. C. T. Jackson, chemist, and Dr. J. C. Warren, then professor of anatomy in the Medical School of Harvard University, one of the surgeons of the Massachusetts General Hospital, and perhaps the leading surgeon in the New England States.

As other surgical cases were not immediately available, it was determined to test the anæsthetic in the extraction of a tooth, Dr. Warren consenting that the experiment should be made before his class at the college. Wells, accompanied by Morton, who took with him his instruments, went to the college in the evening, and Wells administered the gas to a patient and extracted a tooth, but, owing either to some defect in the preparation of the gas or the insufficient amount exhibited, the anæsthesia was quite incomplete, the patient made considerable outcry, and the students and other spectators present laughed and hissed, much to the discomfiture of the unhappy inventor, who, filled with chagrin at his failure, returned home the following morning, too much discouraged to make further trial of his process. In a few months he abandoned his profession and engaged in other pursuits.

The visit to Boston was, however, destined not to be fruitless: it cannot be doubted that it had a decisive influence in fixing the attention of Morton upon the subject and of familiarizing his mind with the idea that surgical anæsthesia was possible.

W. T. G. Morton was then in the twenty-sixth year of his age. He had for a number of years been engaged in the practice of dentistry, and, being desirous of obtaining a medical degree, had in March, 1844, entered his name as a medical student in the office of Dr. C. T. Jackson, subsequently, in the autumn of the same year, matriculating in the Harvard Medical School. During the spring and summer of this year his attention was first directed to the subject of anæsthesia through the recommendation to him, by Dr. Jackson, of "chloric ether," a solution of chloroform in alcohol, as a local application for toothache. The successful application of this remedy in several cases caused him to investigate the subject of the physiological effects of ether upon the animal economy. Dr. Jackson informed him of the intoxicating effects he had seen it produce upon medical students, who in that day frequently inhaled it as a matter of experiment, just as they did nitrous oxide gas; and Morton, having full access to his preceptor's library and chemical laboratory, was soon in possession of the leading facts then known upon the subject.

A portion of the summer months was spent in this line of investigation and in experiments made upon birds and other animals, these

being without satisfactory results—a failure easily accounted for by the variable and uncertain character of ethereal substances as then prepared. With the following winter came the failure of Wells with nitrous oxide gas, as already related, and Morton, becoming absorbed in professional engagements, gave but little further attention to the subject until the spring of 1846, when he renewed his experiments with ether and succeeded in completely anæsthetizing a dog. Encouraged by this result, he determined to devote himself almost exclusively to the investigation of the subject, and that he might have more leisure for experimentation, and thus the more speedily perfect a practical anæsthetic process, he secured the services of an assistant and placed almost the entire management of his large practice in his hands. Anæsthesia had become the dominant thought of his life.

Morton's first experiments with the human subject were made tentatively upon himself with chloric ether and morphine, and subsequently with sulphuric ether: with neither drug was complete anæsthesia attained. He then, after some persuasion, induced a student in his office, Thomas R. Spear, who had previously inhaled ether at Lexington Academy, where he received his education, to again submit to the experiment. The effect did not extend much beyond the stimulant stage. Another student, William P. Leavitt, then inhaled the ether with equally incomplete results, excitation and not the insensibility sought for being produced. A subsequent analysis of the ether used in these experiments showed that it was an impure article, it containing a large percentage of alcohol, water, and acids, this fact sufficiently accounting for its failure to act.

Morton was not then sufficiently acquainted with the chemistry of the ethers to understand the reason for this variability in the action of different specimens, and he thought that more uniform and satisfactory results might perhaps be obtained by the use of an inhaling apparatus made from a nitrous oxide gas-bag, in which the ether was to be placed, the bag to be provided with a valve for the admission of atmospheric air. He determined to borrow for this purpose a bag from the laboratory of Dr. Jackson, and also, if opportunity offered, to obtain from him such information as he possessed concerning the different qualities and preparations of ether. These inquiries were purposely made in a very guarded manner, he fearing to be forestalled in his invention should Jackson obtain a knowledge of the full scope and purposes of his research.

According to Morton's statement,[1] he led the conversation from Wells's experiment with nitrous oxide to the use of ether, it having, as has been seen, long been known that the effects were analogous. Dr. Jackson remarked that ether might be used—that the patient would be dull and stupefied and unable to help himself, the idea evidently being not so much that pain would be abolished as that in the partially stupefied state resistance would be overcome. Dr. Jackson recommended a highly rectified article of ether, and for an inhaling apparatus gave him a flask to contain the ether, with a glass tube through which the vapor might be drawn.

[1] *Memoir to the Academy of Arts and Sciences at Paris*, 1847.

The results following this conference are perhaps best given in Morton's own words (*Memoir*):

"I procured the ether from Burnett's, and, taking the tube and flask, shut myself up in my room, seated in the operating-chair, and commenced inhaling. I found the ether so strong that it partially suffocated me, but produced a decided effect. I then saturated my handkerchief and inhaled from that. I looked at my watch, and soon lost consciousness. As I recovered I felt a numbness in my limbs, with a sensation like nightmare, and would have given the world for some one to come and arouse me. I thought for a moment I should die in that state, and that the world would only pity or ridicule my folly. At length I felt a slight tingling of the blood in the end of my third finger, and made an effort to touch it with my thumb, but without success. At a second effort I touched it, but there seemed to be no sensation. I gradually raised my arm and pinched my thigh, but I could see that sensation was imperfect. I attempted to rise from my chair, but fell back. Gradually I regained power over my limbs and full consciousness. I immediately looked at my watch and found that I had been insensible between seven and eight minutes.

"Delighted with the success of this experiment, I immediately announced the result to the persons employed in my establishment, and waited impatiently for some one upon whom I could make a fuller trial. Toward evening a man residing in Boston (Eben Frost), whose certificate is in the Appendix, came in suffering great pain and wishing to have a tooth extracted. He was afraid of the operation, and asked if he could be mesmerized. I told him I had something better, and, saturating my handkerchief, gave it to him to inhale from. He became unconscious almost immediately. It was dark, and Dr. Hayden held the lamp while I extracted a firmly-rooted bicuspid tooth. There was not much alteration in the pulse and no relaxation of the muscles. He recovered in a minute, and knew nothing of what had been done to him. He remained for some time talking about the experiment, and I took from him a certificate. This was on the 30th day of September, 1846."

A fortunate combination of circumstances rendered this experiment successful. As there was no muscular relaxation, and as the time was very brief in which the ether was inhaled, it is evident that the anæsthesia had not advanced much beyond the first stage when the tooth was extracted. This would not have sufficed for a prolonged operation, and with a weakened heart the shock resulting from imperfect anæsthesia might have been fatal. The patient, however, was robust and vigorous; the pain of his aching tooth was almost immediately relieved by the first inspirations of ether; he breathed in the vapor eagerly and succumbed readily to its influence; and the tooth was extracted before the tetanic or convulsive stage, usually very violent with muscular men, came on. The limited amount of ether given favored speedy recovery and prevented subsequent malaise.

These highly favorable results all tended to inspire Morton with confidence in the safety of the etherizing process. Any one of the many complications constantly occurring during the administration of anæsthetics, even when given by the most experienced operators, might have so alarmed him as to put a stop to all further experimentation. A fatal result would doubtless have postponed the discovery for many years.

Morton immediately determined to bring his discovery to the attention of the medical profession, and called upon Dr. Warren, who, undeterred by the failure of the nitrous-oxide-gas experiment, promised his co-operation, and soon sent him a written invitation to make a practical test of his invention in the Massachusetts General Hospital.

Upon the appointed day, October 16, 1846, the clinic-room of the hospital was well filled. Among the spectators drawn thither by rumors of the intended experiment were several of the leading physicians and surgeons of Boston. The patient selected by Dr. Warren for the operation was a man apparently about twenty-five years of age, who had a vascular tumor about the size of a horse-chestnut situated on the left side of the neck, the removal of which was somewhat dangerous owing to its relations to important nerves and blood-vessels. A delay of some ten or fifteen minutes occurred in consequence of the non-arrival of Dr. Morton at the hour of his appointment, 10 A. M. Dr. Warren, not caring to wait longer, remarked, "As Dr. Morton has not arrived, I presume he is otherwise engaged;" which observation was greeted with a hearty laugh by the expectant but sceptical audience in waiting. Dr. Warren had just taken up his knife to make the first incision in the tumor when the tardy inventor appeared, and stated as an excuse for his delay that he had awaited the completion of a newly-designed inhaling apparatus. This consisted of a glass globe containing a sponge saturated with ether, the vapor of which was drawn into the lungs through a glass tube, a valvular arrangement preventing the products of expiration from entering the globe and thereby contaminating the anæsthetic. This valvular attachment was the new feature in the inhaler, and had been suggested to Morton only the night before by Dr. A. A. Gould of Boston, and, hardly in a completed state, had been snatched from the hands of the instrument-maker only a few minutes before Morton's appearance in the amphitheatre. Thus with a new and untried inhaling apparatus the success of the experiment was, most unwisely, subjected to an additional hazard.

As a witness to the credibility of his statements in regard to the previous success of his anæsthetic process Morton had induced Mr. Eben Frost, his first patient, to accompany him to the hospital, where he was introduced to the notice of the man about to be operated upon, doubtless with a reassuring effect.

As the administration of the anæsthetic began the scene, as described many years ago by Dr. Morton in the presence of the writer, was not without the elements of dramatic interest. Before him rose, tier on tier, the crowded seats of the amphitheatre where he had often sat as a student, while around him, eager to watch the event, were many of the most learned and skilled physicians and surgeons of the city, some of whom had been his teachers, but who were now about to learn from him a lesson which all their wisdom had not compassed, and yet a lesson so transcendently important that in the interests of humanity they might well have bartered all their science for the one thought teeming in the brain of the obscure man before them.

In some four or five minutes the patient succumbed to the influence of the anæsthetic, and Dr. Warren began to operate, and in five minutes

more the tumor was removed. The groans and movements of the patient indicated that sensation had not entirely been abolished, but upon awakening he declared that he had felt no pain, but only a sensation as though the incised parts had been scraped with a blunt instrument. All present were impressed with the great degree of success which had attended the experiment, although Dr. Warren very naturally declared that further trials would be required to settle its value. These followed in rapid succession, the next trial being had the following day, when a woman had a tumor removed from her shoulder by Dr. Hayward, this surgeon operating at the request of Dr. Warren, although it was the latter's tour of duty at the hospital. The operation was entirely successful.

In the following month, November 7, was made what was considered a crucial test, the power of the anæsthetic in capital operations. This consisted in an amputation above the knee by Dr. Hayward, and the excision of the lower jaw by Dr. Warren, the amputation being entirely painless and the suffering incident to the excision being greatly mitigated. The seal of success was thereby placed upon the discovery.

Up to this time the nature of the agent used had not been formally announced; indeed, the odor of the ether had been partially disguised by aromatic oils; still, according to the testimony of Dr. Bigelow, most of the surgeons knew what the active agent in the compound really was. Before the performance of the operations of November 7, however, it was determined by the hospital staff "to decline the use of the preparation until informed what it was;" and this resolve was communicated to Dr. Morton, who in a letter to Dr. Warren immediately expressed his willingness to "give to the surgeons of the hospital any information in addition to that they may now possess," and who subsequently, upon the day of the amputation, publicly announced to the surgeons in the amphitheatre of the hospital that the substance he employed was sulphuric ether, thus removing the objections they had entertained to the use of a secret preparation.

Dr. Morton's action in thus concealing the real nature of his anæsthetic until its success was assured and his position as a discoverer fully recognized can hardly be cavilled at: the simplest dictates of prudence demanded reticence up to that point. But, unfortunately for his fame, he made the effort to control the use of the invention in his own interest by means of letters patent, which were issued to him Nov. 12, 1846, by James Buchanan, then Secretary of State. On December 21, 1846, an English patent was obtained, it being issued, in Morton's interest, to an English citizen, who subsequently surrendered it into Morton's possession through assignment.

Associated with him in the American patent was Dr. Jackson, who had made upon Dr. Morton a demand for five hundred dollars as a compensation for suggestions made and advice given during the progress of his investigations in regard to the nature of ether. Dr. Jackson, by the earnest advice of Mr. Eddy, the patent-agent employed by Morton, who thought it important to have the indorsement of the distinguished chemist's name as a scientific backing to the discovery, was accepted as a joint discoverer, and 10 per cent. of the prospective profits arising

from the sale of licenses under the patent was awarded him in lieu of the five hundred dollars which were the amount of his original claim.

Dr. Jackson, although a member of the Boston Medical Society, consented to share in the patent right upon the basis that while the laws of the society provided that no member should deal in secret remedies, the patenting of the invention would destroy its secrecy, and thus his standing in the society would remain unimpaired. This liberal interpretation of the provisions of the code of ethics, however, resulted in but small gain to either of the parties interested: a few office-licenses were sold, but the Government failed to recognize the validity of the letters patent issued by itself: ether came into general use in the army and navy, and, indeed, throughout the country, without compensation to the discoverer.

It is hardly the place to enter into a discussion of the abstract question of patent rights as applied to agents intended for the relief of human suffering: the general disfavor with which such restrictions are viewed is perfectly natural, although, perhaps, not very logical, inasmuch as many inventions in the mechanic arts, in household appliances, etc. are quite as important to human welfare as those which come under the interdicted class. But, apart from this, the degree of censure which should attach to Dr. Morton in the matter under consideration must be determined in the light of all the circumstances under which he was placed. He was not, like Dr. Jackson, a recognized member of the medical profession, and therefore was not in honor bound to an observance of both the letter and spirit of its code of ethics —a code which demands from each the fullest recognition of the rights of all, and from all the unreserved interchange of the fruits of learning, observation, and experience. The dental profession, with which he was associated, had hardly begun to be recognized or organized as such: its first national society and its first college had been but a few years in existence, and the period had hardly elapsed in which, as far as possible, all processes in dental art were the carefully-guarded secrets of men who would impart them only for a consideration, and then under the strictest injunctions of secrecy.

Still, the better element in the dental profession was even then, as will presently be seen, outspoken in its opposition to patents as antagonistic to professional growth and subversive of the general good. Morton knew the sentiment, and should have respected it. Taking all the conditions into consideration, however, the obtaining of a patent by him cannot be accepted as an evidence of moral turpitude: the most that can be said of it is that it was an error in judgment, and this he very speedily recognized and admitted. In a letter to the American *Journal and Library of Dental Science* (vol. viii., No. 1, October, 1847) this avowal is frankly made, and an equally frank explanation is given of the motives by which he was impelled. This passage in the letter perhaps constitutes Morton's best defence, and is here reproduced:

"I feel bound to make an explanation on the subject of the patent which I obtained. My intention had been chiefly to discover something which I could use to advantage in dental operations. The other uses to which it could be put were collateral to my purpose, and I had no desire to inter-

fere with them. But I was advised that if I did not procure a patent my discovery and the instruments by which I administered the ether would be used by other dentists, while I, who had devoted my time, money, and labor to it, and had run all the risks and encountered all the opposition, odium, and ridicule, would receive no greater reward than they. I did not at the time fully realize the manifold uses and extraordinary powers which have since been developed. I was also advised that this would be a dangerous instrument for evil, and that public policy would be subserved by confining its use to responsible parties. I immediately presented the right to all charitable institutions in the United States, together with apparatus to many of them, and made it known that I would give every facility for its use for the smallest compensation in surgical cases, and would sell rights to dentists for a consideration which all would admit to be reasonable. My object was to secure to myself a reasonable return for the discovery and for all that I had undergone and risked in its prosecution. I can sincerely say that I now regret having taken this step, but a man's motives should not be judged by the result: he must be judged according to the circumstances under which he acted. As I have now abandoned all intention of adhering to the patent, I wish also to have the result of my efforts understood. So far from having gained, I have been a pecuniary loser, by this discovery. It took me from my business, which I was obliged to confide to other hands, involved me in outlays bringing no return, and in personal controversies, and now the discovery is freely used by those very persons whose opposition caused me for a time so much loss and inconvenience."

Opposition to Etherization.—The intimation here given that "opposition, odium, and ridicule" was the lot both of the discoverer and his discovery will hardly excite surprise in the minds of those who remember how generally this has been the reward accorded by men to those who have most benefited mankind; and the record of the events now under consideration would not be complete without some reference to the nature and extent of these antagonisms.

Morton found his most active opponents in the ranks of his own profession. In Boston this opposition was organized, a meeting of dentists being called and a committee of twelve appointed, who prepared and published in the leading newspaper of that city a formal protest against etherization, many instances being cited in which failure of the process or injury to the patient, such as continued delirium and pulmonary hemorrhage, had been the result of the use of the agent by Dr. Morton. As a fair specimen of the tone and animus of many of the attacks upon the new agent with which the press of that day was rife, the following extracts are given from a letter written December 15, 1846, by Thomas E. Bond, Jr., M.D., professor of special pathology and therapeutics in the Baltimore College of Dental Surgery, to the editor of the *Boston Medical and Surgical Journal*:[1]

"I protest against the whole business, because I verily believe the great discovery to be utterly useless. If it does not succeed better in Boston than in other places nearer to your humble servant, I would not give a farthing for it. In this part of the world it has utterly failed to do what it ought to do, and unfortunately it has done what it ought not to have done.

[1] Reproduced in the *American Journal and Library of Dental Science*, vol. vii., No. 3, March, 1847.

In one instance it produced distressing sensations about the chest, which warned the inhaler to let it alone, and he has a teasing cough placed to the debtor side of the account. In another the patient did not get insensible, but got drunk, and boxed the surgeon-dentist's jaws as his reward for administering the intoxicating vapor.

"But you will say, 'The cases! the cases! Dr. Bigelow's cases! Dr. Warren's cases! the Massachusetts Hospital cases! are they not satisfactory?' No, Dr. Smith, they are not. They savor prodigiously of 'mesmeric' incantation. Do you remember one Dr. Collins, whom a number of the Boston faculty sent to us some years ago armed with professional certificates, all testifying to his 'charming' powers? Pardon me: we are a little suspicious of our Boston brethren since that time. They are clever men, very clever, but—some of them—a little credulous. . . . . These cases, we are told, are fair examples of the average results produced by the inhalation of ether. It is likely they are, and they convince us that ether has precisely the power it was known to have had at least, as we have evidence at hand to show, twenty-five years ago, when in certain cases it produced a degree of narcotism at the expense of great bronchial irritation, and even, as was then supposed, fatal pulmonary disease. Heretofore surgeons have declined using this agent, because they were aware that lethargy and fatal coma were conditions divided by a line of separation too indistinct to permit of the production of insensibility with impunity, and because pulmonary irritation is a more serious evil than pain.

"The truth is, that what your correspondents are pleased to call, in medical parlance, 'producing insensibility' is, in fact, making people 'dead drunk.' Everybody knows that when a man is in this curious condition he is very insensible to pain. A poor Irishman in this neighborhood while in this state of 'insensibility' had both his legs taken off by a locomotive. He manifested so little 'sensibility' that he was not aroused until a surgeon was amputating the shattered stumps, when he cried out, 'Don't be cutting me; me flesh is aisy to hale.' Can ethereal vapor beat this exploit of whiskey? I trow not. Now, doctor, if we are to induce insensibility by this class of means, I very much prefer whiskey-punch to ether, because it is more certain and more permanent in its effects: it is less dangerous; and lastly, it will be easier to persuade patients to take it. Moreover, I have the same right to patent whiskey-punch for this purpose that Mr. Morton has to patent ether, for I do not know that such an application of the article has been made before."

Very much of the antagonism of which this letter was a manifestation was unquestionably due to Morton's unfortunate patent-right experiment. Dr. Bigelow had offered in extenuation of this mistake the illogical plea that the discovery was primarily one in "mechanical dentistry," and that therefore a patent was permissible. To this the editors of the *American Journal and Library of Dental Science* made the following spirited reply:[1] "The pretensions set up by Dr. Bigelow, that it is proper and right to patent inventions in mechanical dentistry, is too absurd, too offensive to the good sense, honorable feeling, and correct practice of respectable dentists, to be worthy of refutation. There is no conventional understanding among us to permit such patent-mongering. We think, indeed, that we could name quite as many respectable physicians who are disgracing their profession by vending

[1] Dec., 1846, vol. vii., No. 2, p. 195.

nostrums as he can discover dentists of acknowledged standing engaged in such practices."

In another issue of the same journal (October, 1847) occur the following editorial remarks: "A liberal profession like ours, devoted to the amelioration of the condition of humanity, a profession which joins hand in hand with the noble one of medicine and surgery in bestowing happiness and relief on our great brotherhood of the human race, so far as regards the *profession* have no right to secrets and patents; and should any of its members become obstinate in regard to their professed 'rights,' they at once rebel against the spirit of our fraternity, forfeit all claims to our countenance, and should be regarded accordingly."

The same writer states that "Dr. James H. Bickford has addressed to the *London Morning Chronicle* a solemn warning against the use of ether. He denies that the insensibility which it produces is no worse than that of drunkenness or asphyxia. There is a chemical alteration in the vital constituents of the blood; for not only is that deprived of its oxygen and of the power of coagulation—like the black, vitiated blood of malignant and putrid fever—but the corpuscles, whence fibrin is formed, are actually dissolved. Hence the blood takes a long time to regain its life-supporting, flesh-forming character, wounds show wasted edges and refuse to heal, and the patient often sinks into death. The use of ether also tends to produce tubercular consumption of the lungs: in thirty cases of death after the use of ether in the Dublin hospitals the deaths could be traced to recent tubercles believed to be the product of ether." For this and analogous reasons the writer concludes that "the ether excitement has evidently had its day, and is destined soon to be superseded by that healthful reaction of common sense which follows extremes in medicine as well as other sciences."

Even more alarming than the above was the following vaticination, which, according to a writer in the *North British Review*,[1] was but one among the many then rife in the public prints: "It is useful to remind those who surrender themselves unreservedly to experiments of this nature that the vapor of ether, when combining with the air, constitutes an explosive gaseous mixture of the most dangerous kind. . . . . Now, if it be considered that the vapor-laden air inspired by a patient about to be operated on is precisely this explosive mixture, ... an idea may be formed of the fate that awaits the patient if fire should unhappily reach the air which he is inhaling. A sudden explosion will communicate itself to the interior of his chest, tear the bronchi throughout their entire ramifications, and literally reduce to atoms one of the most essential of the organs of life."

"For some time," says the reviewer, "the profession stood abashed at this, and instrument-makers were seized with a fit of contriving so as to avoid all such risk, protecting every accessible point with wire gauze, such as is used in the safety-lamp of Davy, constructing new valves, etc. etc. A simple though bold experiment, however (a lighted paper to the mouth of an etherized patient), put all happily at rest."

Religious objections to the use of anæsthetics were also urged, many, inspired by ignorant fanaticism, claiming that pain being a dispensation

[1] May, 1847, p. 104.

of Providence, it was in contravention of the divine purpose to alleviate or mitigate it through artificial agencies. The opposition to the use of anæsthetics in obstetrical practice was specially formidable, this being chiefly based upon the passage in Genesis (chap. iii. 16): "Unto the woman he said, I will greatly multiply thy sorrow and thy conception: in sorrow thou shalt bring forth children." Prof. Simpson even thought it necessary to devote an entire chapter in his work on anæsthesia to an elaborate argument in proof of the position that the word "sorrow" in this passage does not necessarily involve the idea of physical suffering. He quotes from a letter written by a clergyman to a medical friend, in which anæsthesia is spoken of as "a decoy of Satan, apparently offering itself to bless women; but in the end it will harden society and rob God of the deep, earnest cries which arise in time of trouble for help." Dr. Simpson states that "lecturers on midwifery in London and Dublin publicly adopted the same line of opposition and argument." Even the late Dr. Charles D. Meigs, professor of midwifery and the diseases of women and children in the Jefferson Medical College of Philadelphia, wrote in 1856[1] of the "doubtful nature of any processes that the physician sets up to contravene the operation of those natural and physiological forces that the Divinity has ordained us to enjoy or to suffer." In justice to Dr. Meigs, however, it must be stated that his opposition was based chiefly upon physiological grounds. Upon this basis, too, many surgeons and physicians objected to the anæsthetic procedure in any surgical operation, they affirming pain to be salutary and desirable because promotive of the reparatory process in wounded surfaces.

In Philadelphia the opposition to anæsthesia was very persistent—so much so, indeed, that in the course of a discussion at the meeting of the Philadelphia County Medical Society (April 13, 1852) Dr. H. S. Patterson was constrained to say that "the mass of resistance to the use of anæsthetics has been more obstinate and impregnable here than anywhere else in Christendom, and our hospital—alone among great hospitals—has never permitted their employment."

One of the earliest to recognize the practical value of the new discovery was A. Hill, D. D. S., of Norwalk, Conn., who published his experience in a communication to the *American Journal and Library of Dental Science*.[2] In this he states that he had purchased from Dr. Morton a license for the use of the "Letheon" (the name which had been given to the new agent), and gives a very clear and practical account of his experiences, the following being his conclusions:

"1st. That in the hands of *careful, skilful*, and *judicious* men the Letheon is perfectly safe.

"2d. That where there is a failure it is the result of an imperfect preparation of the vapor or an imperfect inhalation, modified, perhaps, in some cases by peculiar temperament.

"3d. That it is not only safe, but valuable beyond conception in a multitude of cases."

European Recognition.—Outside of Boston, Morton's discovery met with the warmest and most immediate recognition in England. According-

[1] *Treatise on Obstetrics.*

[2] Vol. vii., No. 3, March, 1847.

ing to Dr. Bigelow,[1] the first public announcement of surgical anæsthesia was made by him in a paper in the *Boston Medical and Surgical Journal,* Nov. 18, 1846, entitled "Insensibility during Surgical Operation produced by Inhalation, read before the Boston Society for Medical Improvement, Nov. 9, 1846," an abstract having been previously read before the American Academy of Arts and Sciences, Nov. 3, 1846. "A copy of this," says Dr. Bigelow, "was sent by a gentleman to his friend Dr. Booth of London." The important intelligence was immediately communicated by him to Liston, the distinguished surgeon, who, Dec. 21, 1846, in the hospital of the University College, practically and successfully tested the discovery. This result he immediately communicated to his former pupil, Prof. Miller of Edinburgh, in the following enthusiastic epistle:

"Hurrah! rejoice! Mesmerism and its professors have met with a 'heavy blow and great discouragement.' An American dentist has used ether (inhalation of it) to destroy sensation in his operations, and the plan has succeeded in the hands of Warren, Hayward, and others in Boston. Yesterday I amputated a thigh and removed by evulsion *both* sides of the great toe-nail without the patients being aware of what was doing, so far as regards pain. The amputation-man heard, he says, what we said and was conscious, but felt the pain neither of the incisions nor that of tying the vessels. In short, he had no sensation of pain in the operating theatre. I mean to use it to-day in a case of stone. In six months no operation will be performed without this precious preparation. It must be carefully set about. The ether must be washed and purified of its sulphureous acid and alcohol. Shall I desire Squire, a most capital and ingenious chemist, to send you a tool for the purpose? It is only the bottom of Nooth's apparatus, with a sort of funnel above, with bits of sponge, and at the other hole a flexible tube. Rejoice!

"Thine always, R. L."

This letter of course excited the utmost interest in the minds of the profession in Edinburgh, and Prof. Simpson, then professor of midwifery in the University of Edinburgh, soon after visited London, where he had opportunities of seeing practical demonstrations of the success of the new discovery, and, returning home with an inhaling apparatus (which was still considered indispensable), successfully tested it in a case of amputation performed by Dr. Duncan in the Royal Infirmary.

With almost unexampled rapidity news of the discovery spread throughout the civilized globe, and in all civilized countries the anæsthetic process was generally adopted in surgical operations. On Jan. 19, 1847, Dr. Simpson extended its use to the alleviation of the pangs of childbirth in a case of midwifery which came under his care at that date, this being the first case on record.

Chloroform as an Anæsthetic.—In consequence of the unpleasant effects, such as bronchial irritation, etc., sometimes produced by ether inhalation, Dr. Simpson was led to experiment with other volatile agents, and to obtain from his chemical friends all the information he could concern-

[1] "A History of the Discovery of Modern Anæsthesia," *American Journal of Medical Sciences,* Jan., 1876.

ing them. He found in chloroform what he conceived to be an excellent substitute for ether, free from its objectionable features and more prompt in its action. These advantages soon obtained for it so widespread a popularity that for a time it seemed as though etherization would become obsolete, as, indeed, in England it nearly did. So great was the reputation Dr. Simpson obtained through the introduction of chloroform narcosis that the fame of Morton was in the minds of many quite overshadowed. Even so late as 1869 the then Sir James Y. Simpson, upon receiving the honorary burgess-ship of Edinburgh, was greeted by the lord provost, William Chambers, Esq., the well-known author and publisher, as the author of "the greatest of all discoveries in modern times, the application of chloroform to the assuagement of human suffering"—so little were the value and true nature of the service which Morton had rendered to humanity appreciated by even so cultured and intelligent a gentleman as the lord provost in question.

The Ether Controversy.—It is now proposed briefly to review the causes by reason of which Morton's fairly-won fame was thus obscured, and through which opinion is to-day still so divided as to whom should be given the chief credit for so great a discovery. In part, his failure to obtain complete recognition grew out of the somewhat mercenary aspect in which his pretensions to secrecy and his securing of letters patent placed him. This result, however, was of but minor importance. So far as his claims as a discoverer were concerned, the chief mischief arising from the effort to secure control of the anæsthetic agent through a patent was the fact that by the unwise advice, already alluded to, of his patent-agent, Mr. Eddy, he was induced to admit the claims of Dr. Jackson as a joint discoverer.

No sooner was the success of the discovery fully established than the latter came forward as the sole originator of the anæsthetic idea and the instigator of the experimentation conducted by Morton, who, it was claimed, was merely a subsidiary agent in the affair. In order that Morton's claims might be completely forestalled in continental Europe, Jackson, who, as Dr. Bigelow says, "knew the machinery of fame," sent letters to the French Academy of Sciences—one dated November 13, and the other December 1, 1846—in the first of which he announces the discovery, and states that he had *induced* "a dentist" (not even mentioning Morton's name) "of this city to administer the vapor of ether to persons from whom he was to extract teeth," and that he then "*requested* this dentist to go to the General Hospital of Massachusetts and administer the vapor of ether to a patient about to undergo a painful surgical operation." In the second letter he announces the complete success of the experimentation with ether, and that "it has been put into use with full success in the General Hospital of Massachusetts."

These letters were presented to the French Academy by M. Élie de Beaumont, to whose care they had been entrusted by Dr. Jackson, and who had kept them in a sealed packet until the session of January 18, 1847, when they were opened and read. Knowledge of the discovery, however, had reached France at a much earlier period than this, and etherization had been practised by Velpeau and others; but the claim

of discovery thus formally presented accomplished, for the time at least, its purpose.

The claims of Morton were subsequently so fully and forcibly presented that they could not be entirely ignored, and the Academy at the session of March 4, 1850, decreed a prize of twenty-five hundred francs to Dr. Jackson, "for his observations and his experiments on the anæsthetic effects produced by the inhalation of ether; and, likewise, another of twenty-five hundred francs to M. Morton, for having introduced that method in surgical practice in conformity with the indications of M. Jackson."[1]

The nature of the claim upon which this award was based will now be examined.

As given by Dr. Jackson himself in a statement addressed to a committee appointed by the House of Representatives of the United States to investigate the subject of the ether discovery (see official Congressional reports), the date of his discovery of anæsthesia by ether vapor was in the winter of 1841–42. During this winter he was engaged in giving lectures on chemistry, and accidentally inhaled a large amount of chlorine gas, which resulted in a severe inflammation of the throat attended by considerable pain, to relieve which he inhaled perfectly pure washed ether, of which he had in his laboratory a large supply. This resulted in loss of feeling and cessation of pain, and finally loss of consciousness, from which he recovered to find the nerves of sensation still partially paralyzed, some time elapsing before his throat became again painful. Reflecting upon this experiment, the idea of etherization during surgical operations flashed into his mind. He states that he, like all educated physicians and physiologists, knew that "the nerves of sensation were distinct from those of motion and of organic life, and that one system might be paralyzed without necessarily and immediately affecting the others;" that he had observed this sequence of influences and results during his inhalation of the ether vapor; and that "this state of insensibility of the nerves of sensation continued for a sufficient length of time to admit of most surgical operations; . . . . that the nerves of motion and of the involuntary functions of respiration and of circulation were in no wise affected, the functions of life going on as usual, while the nerves of sensation were rendered devoid of feeling and the body could suffer no pain. By long experience in the trial of ether vapor in spasmodic asthma, and from numerous carefully-conducted physiological experiments, I had learned that the vapor of ether could be safely inhaled into the lungs to an extent before believed to be highly dangerous."

So that, according to Dr. Jackson's own statement, he had in the winter of 1841–42, by scientific induction based upon partial experimentation, arrived at a full conviction of the possibility of artificial anæsthesia by means of ether vapor during surgical operations, and yet made no effort to put it to practical use until the winter of 1846, when, as the result of an accidental encounter and conversation with Dr. Morton (see p. 36), he mentioned ether to him as a means for stupefying a patient prior to the extraction of a tooth. This reticence is all the

[1] *Comptes rendus.*

more noteworthy because in the winter of 1844–45 he was cognizant of the visit of Dr. Wells to Boston for the purpose of demonstrating his nitrous-oxide-gas discovery, and, indeed, had had an interview with him, and still had given neither to him nor to Morton, his student, any hint as to his knowledge of the fact that ether vapor would accomplish what nitrous oxide gas had failed to effect. Certainly, this withholding of a truth of such importance for so great a length of time is in sufficiently marked contrast with the swift eagerness with which Morton confirmed hypothesis by experiment and made the result known to the whole world. It is true that, according to the sworn evidence of several reputable persons, Dr. Jackson had during the period between 1842 and 1846 suggested etherization to them, but in the greater number of instances it was in connection with chlorine inhalation. Several of the witnesses, however, testify that distinct mention of the possible anæsthetic powers of ether in dental and general surgery was made.

Jackson's failure to make known his discovery is accounted for by his friends by the entire absorption of his time and the preoccupation of his thoughts in geological and chemical research and experimentation; that, having retired from the practice of medicine, he had no facilities for making experiments; and that he "naturally shrank from going to the hospitals, where chemists are regarded with distrust and jealousy by the surgeons, and where, as events have shown, the largest honor of successful experiment would have been claimed by the verifiers." Moreover, it is claimed that it was in keeping with his peculiar mental constitution to be cautious and slow in making his scientific discoveries known to the world, as in the asserted fact of his discovery of chlorine in meteoric iron in 1834, of which he published no account until the year 1838.

From a review of all the evidence it would appear altogether probable that Jackson, as well as Morton, had conceived the idea of artificial anæsthesia by ether. The history of the subject fully establishes the fact that the anæsthetic idea had been, and was, in the minds of many men. Dr. J. C. Warren testifies that *he* had been anxious to find something of the kind proposed by Morton, and had made repeated trials without any satisfactory result; hence, probably, the favorable reception he was prepared to give to Morton's request for an opportunity to test his discovery.

It is in evidence that ether had been suggested to Dr. Wells after his early nitrous-oxide experiments by E. E. Marcy, M. D., and it is even claimed that a surgical operation was performed by the latter in 1844 while the patient was anæsthetized by ether vapor, the use of this agent, however, being abandoned in favor of nitrous oxide gas as being the safer and more reliable of the two.

An even earlier and much better authenticated claim of priority of use is that of Dr. Crawford W. Long of Athens, Ga., who claims to have operated under ether so early as July 3, 1842, and to have repeated the experiment on Sept. 9, 1843, and Jan. 8, 1845, the claim for the operation in 1842 being fully substantiated by the affidavit of the patient and by the usual entry of fee in his daybook.

M. Ducros claims priority, because at the séance of the French

Academy held March 16, 1846, he announced that he had "employed with success sulphuric ether to produce sleep in persons afflicted with hypochondria, and who had for that purpose vainly employed opiates." The method of administration employed by M. Ducros was "frictions upon the tongue, soft palate, tonsils, and fauces," and he stated that, employed in the same manner upon chickens, sleep had been instantaneously produced.[1]

Robert H. Collyer, M. D., of London, writes quite indignantly to the editor of the *Medical Times and Gazette* (Oct. 14, 1871) as follows:

"SIR: Having in my possession the original publication of 1843, wherein I distinctly state that the inhalation of narcotic and stimulating vapors produces an anæsthetic state, prior to which I had performed various surgical operations during this insensible condition, which enabled me to publish the fact in 1843, I cannot now understand how Horace Wells could be named as the originator of modern anæsthesia, when his first essay with nitrous oxide only dates from December, 1844," etc. etc.

Samuel Sexton, M. D., in an article in the *New York Medical Record*[2] calls attention to the use of ether vapor as recorded in a work published in London in 1829 by William Wright, Esq., "Surgeon Aurist to her late Majesty Queen Charlotte," the ether being administered by him in cases where spasmodic cough was liable to be excited by the slightest touch being given to the lining tube of the ear, the method of administration recommended being to put the ether in a receptacle floating in a basin of warm water, the patient breathing in the vapor until all reflex irritability ceased. This plan, he states, was constantly resorted to by himself and patient.

J. Gorringe, Esq., assistant surgeon to the Royal Cornwall Infirmary, in a communication to the *London Lancet*[3] states that while an apprentice to the University College Hospital in the session of 1838–39 he had on several occasions inhaled sulphuric ether from a common bladder until marked intoxicating effects were produced, and that he had a distinct remembrance of two cases of insensibility resulting therefrom, the students falling flat on their backs.

These cases are cited to show that knowledge of the leading physiological effects of ether was not by any means the exclusive property of Dr. Jackson, and that others besides himself had thought of surgical anæsthesia prior to his claimed discovery.

The following quotation from the edition of Pereira's *Elements of Materia Medica*, published in London, 1839—a standard work which Jackson had in his library—shows how much was really known about the drug in question, and how entirely destitute of originality his use of it after inhaling chlorine really was, as well as how thoroughly understood was the analogy between the physiological effect of ether vapor and nitrous oxide gas. Reading this, it is evident that no man acquainted with the facts and giving the slightest attention to the subject could fail, on hearing of experimentation with the one agent for the production of anæsthesia, to think of the other:

[1] *Comptes rendus*, séance du Lundi, 16 Mars, 1846, p. 447.

[2] 1879, vol. xvi. p. 117.

[3] Feb. 13, 1847, vol. i. p. 186.

"The vapor of ether is inhaled in spasmodic asthma, chronic catarrh and dyspnœa, whooping cough, and to relieve the effects caused by the accidental inhalation of chlorine gas. When the vapor of ether, sufficiently diluted with atmospheric air, is inhaled, it causes irritation about the epiglottis, a sensation of fulness in the head, and a succession of effects analogous to those caused by protoxide of nitrogen, and persons peculiarly susceptible to the action of the one are also powerfully affected by the other (*Journ. Science*, vol. iv. p. 158). If the air be too strongly impregnated with ether, stupefaction ensues."

That Morton had a good general knowledge of sulphuric ether, and was not, as claimed by Jackson, wholly ignorant concerning it prior to the visit to his (Jackson's) laboratory, Sept. 30, 1846, is demonstrated by the most positive evidence of reputable chemists, apothecaries, and instrument-makers, who testify that at various times before that date he had made personal inquiries of them about ether; while other witnesses testify to his purchase and possession of samples of that drug. Stronger testimony could not be offered than has been furnished upon these points.

Morton's own statement in regard to his sources of information and the degree of his indebtedness to Jackson very fairly represents the facts in the case. He says:[1]

"I will make a single remark upon the subject of my interview with Dr. Jackson. It is not necessary to go into the question of the origin of all ideas: I am ready to acknowledge my indebtedness to men and to books for all my information upon this subject. I have got here a little and there a little. I learned from Dr. Jackson in 1844 the effect of ether directly applied to a sensitive tooth, and proved by experiment that it would gradually render the nerve insensible. I learned from Dr. Jackson, also in 1844, the effect of ether when inhaled by students at college, which was corroborated by Spear's account and by what I read. I knew of Dr. Wells's attempt to apply nitrous oxide gas for destroying pain under surgical operations. I had great motives to destroy or alleviate pain under my operations, and endeavored to produce such a result by means of inhaling ether, inferring that if it would render a nerve insensible directly applied, it might, when inhaled, destroy or greatly alleviate sensibility to pain generally. Had the ether I tried on the 5th of August been pure I should have made the demonstration then. I further acknowledge that I was subsequently indebted to Dr. Jackson for valuable information as to the kinds and preparations of ether, and for the recommendation of the highly rectified from Burnett's as the most safe and efficient. But my obligation to him hath this extent, no further. All that he communicated to me I could have got from other well-informed chemists or from some books. He did not put me upon the experiments; and when he recommended the highly rectified sulphuric ether, *the effect he anticipated was only that stupefaction which was not unknown, and he did not intimate in any degree a suspicion of that insensibility to pain which was demonstrated and astonished the scientific world.*"

According to the sworn evidence of Caleb Eddy, Esq., of Boston (official reports), Jackson's own words to him confirm this view of the

[1] *Memoir to the French Academy*, July, 1847.

case. Mr. Eddy asked him during a conversation in reference to the new discovery, "Dr. Jackson, did you know at such time" (when recommending ether to Morton) "that after a person had inhaled the ether, and was asleep, his flesh could be cut with a knife without his experiencing any pain?" He replied, "No, nor Morton either: he is a reckless man for using it as he has."

It is very safe to assume that had Morton's "recklessness" resulted in any misadventure Dr. Jackson would not have been nearly so swift to assume a share in the responsibility of the failure as he was to claim all the credit for the success. Dr. Jackson subsequently denounced this "reckless man," Morton, as "an ignoramus and an imbecile, not only not possessed of science, but mentally incapable of acquiring it."[1] It assuredly is but little to the credit of Dr. Jackson's humanity or of his professional discernment that he should have risked human life and perilled the success of his great discovery by placing it in hands so incapable. And yet nothing is more certain than that Morton was permitted to assume the whole responsibility in his grave undertaking. Indeed, so thoroughly aloof did Dr. Jackson hold himself that it was not until the 21st of November, more than a month after the first operation with ether, that he was present during its administration to a patient, and then only as a spectator.

Dr. Jackson's claim to the gratitude of humanity would seem, according to his own showing, to rest upon this: that in the year 1842 he discovered the anæsthetic power of ether, satisfied himself that by its agency the sensory nervous system might be completely narcotized while respiration and circulation remained comparatively unaffected, and that for this reason it might be safely used in surgical operations; that he allowed this great discovery to remain unknown to the world until 1846, and then imperilled the success of his discovery and the interests of suffering humanity by entrusting the administration of so powerful a narcotic as sulphuric ether to the hands of one whom he claims to have known as an ignoramus and an imbecile.

Justice to Dr. Jackson himself would seem to demand that a claim necessarily involving such an implication as this should not be credited. The fact would appear to be that either his ambition or his peculiar mental constitution led him to unduly exaggerate the share he had had in Morton's discovery. Jackson was unquestionably a man of good scientific attainments, and was constantly engaged in general scientific research, and in a vague sort of way had doubtless conceived the idea that ether might be used as a pain-obtunder in surgery—the same idea which Morton and, as has been seen, others hit upon. That the suggestions which he made to Morton should have led him to claim the sole merit of the whole discovery was but in keeping with a previous attempt of the same nature—the claiming in 1837 of the invention of the magnetic telegraph, this assumption being based upon alleged conversations held with Prof. Morse in the year 1832 when they were fellow-passengers during a transatlantic voyage; during which voyage the idea of the electric telegraph was conceived and elaborated in all its essential details by Morse, and by him alone, as was fully and irrefut-

[1] See Majority Report Select Committee of 32d Congress.

ably substantiated before the courts, the judges refusing to concede to Jackson any share, direct or indirect, in the invention.

The claims of the various contestants in the ether controversy also have been fully adjudicated, and before tribunals whose integrity it is impossible to question, and which had the best opportunity of judging of the character of the witnesses and the credibility of their testimony. The case can never again be retried, and their verdict must be accepted as final.

Dr. Morton submitted to the Thirty-second Congress a memorial asking from that body remuneration for his discovery. This memorial was referred to a select committee of the House of Representatives. The majority report of this committee thoroughly reviews all the evidence, and announces the following conclusions:

"1st. That Dr. Horace Wells did not make any discovery of the anæsthetic properties of the vapor of sulphuric ether which he himself considered reliable and which he thought proper to give to the world—that his experiments were confined to nitrous oxide, but did not show it to be an efficient and reliable anæsthetic agent, proper to be used in surgical operations and in obstetrical cases.

"For the rest, your committee have come to the same conclusions that were arrived at by the trustees of the Massachusetts General Hospital at their meeting in January, 1848, and reconsidered" (at the request of Dr. Jackson) "and confirmed in 1849, and adopted by the former committee of the House—viz.:

"2d. That Dr. Jackson does not appear at any time to have made any discovery in regard to ether which was not in print in Great Britain some years before.

"3d. That Dr. Morton in 1846 discovered the facts, before unknown, that ether would prevent the pain of surgical operations, and that it might be given in sufficient quantity to effect this purpose without danger to life. He first established these facts by numerous operations on teeth, and afterward induced the surgeons of the hospital to demonstrate its general applicability and importance in capital operations.

"4th. That Dr. Jackson appears to have had the belief that a power in ether to prevent pain in dental operations would be discovered. He advised various persons to attempt the discovery, but neither they nor he took any measures to that end, and the world remained in entire ignorance of both the power and safety of ether until Dr. Morton made his experiments.

"5th. That the whole agency of Dr. Jackson in the matter appears to consist only in his having made certain suggestions which aided Dr. Morton to make the discovery—a discovery which had for some time been the object of his labors and researches."

The conclusions embodied in this report of the committee of the House of Representatives are fully sustained by the following "Memorial," which may be accepted as the verdict of a "jury of the vicinage." The memorial is signed by all the surgeons and physicians of the Massachusetts General Hospital, and by several hundred of the leading members of the Massachusetts Medical Society, and reads as follows:

"To the Honorable the Senate and House of Representatives of the United States, in Congress assembled:

"The undersigned hereby testify to your honorable bodies that in their

opinion Dr. William T. G. Morton first proved to the world that ether would produce insensibility to the pain of surgical operations, and that it could be used with safety. In their opinion his fellow-men owe a debt to him for this knowledge. Wherefore they respectfully ask a recognition by Congress of his services to his country and mankind."

Many of the men who signed this memorial had personal knowledge of the facts; the men who signed the majority report of the select committee of the House of Representatives were accustomed to weigh evidence. From this joint verdict of Morton's contemporaries there can now be no appeal. It is a verdict fully sustained by the authority of Daniel Webster, then Secretary of State. In a letter to Dr. Morton, dated Washington, December 20, 1851, he says:

"In reply to your letter of the 17th inst. I would say that, having been called on, on a previous occasion, to examine the question of the discovery of the application of ether in surgical operations, I then formed the opinion, which I have since seen no reason to change, that the merit of the great discovery belonged to you, and I had supposed that the reports of the trustees of the hospital and of the committee of the House of Representatives of the United States were conclusive on this point.

"The gentlemen connected with the hospital are well known to me as of the highest character, and they possessed at the time of the investigation every facility for ascertaining all the facts in the case.

"The committee of the House were, I believe, unanimous in awarding to you the merit of having made the first practical application of ether, and a majority by their report awarded to you the entire credit of the discovery."

Although Dr. Morton's memorial to Congress asking for remuneration was thus sustained by the committee to which it had been referred, no grant of money was ever made to him, the failure to secure an appropriation for that purpose being chiefly due to the antagonism not only of the friends of Jackson, but of Wells, the latter being very active in asserting his claim to the chief, if not the entire, merit of the discovery. Similar influences caused the abandonment of a subscription for ten thousand pounds which had been started in England on behalf of Morton, and which had at first every prospect of a successful issue.

The trustees of the Massachusetts General Hospital voted him the sum of one thousand dollars, which was presented to him in a silver casket, upon which was engraved this sentence: "He has become poor in a cause which has made the world his debtor." This and the prize from the French Academy, already mentioned, constitute almost the entire sum of the pecuniary recognition which his great service to humanity received.

Jenner, to whom the world owes its present comparative immunity from one of the greatest scourges of the human race, smallpox, received from the British House of Commons thirty thousand pounds as an acknowledgment of the gratitude of the nation for the invention of vaccination. It would be difficult to determine whether Jenner's invention or the discovery of anæsthesia has been the more wide-reaching in its beneficence: both are priceless gifts to mankind, and it is but little to

the credit of the American republic that it should have permitted Morton to suffer in mind, body, and estate, and to go down to his grave an impoverished man—"the only person," to use his own language, "in the whole world to whom the discovery was a pecuniary loss."

Jenner's discovery was based upon the observation of a young countrywoman, who, while he was a student at Sudbury, made to him the remark, in connection with the subject of smallpox, "I cannot take the disease, for I have had cowpox," this being a popularly received idea in that district; but the fact that this remark first fixed Jenner's attention upon the subject did not prevent the House of Commons from recognizing the truth that to his persistent and indomitable energy, manifested in the face of storms of obloquy and persecution, humanity owes the demonstration of the scientific truth of what had before been merely surmise.

The same truth should have been recognized—indeed, was recognized—in the case of Morton. Whatever else may be questioned, the fact is undisputed and indisputable that he was the first to demonstrate to the world the practicability of anæsthesia as a system reasonably certain, safe, and uniform in its operations. For this, if for this alone, he should have been rewarded, and with no niggard hand.

Morton in making this demonstration assumed no small risk and responsibility; indeed, his courage has been termed audacity. As Dr. Bigelow says: "Had Morton been a timid or discreet man, anæsthesia might have been delayed beyond the present generation. Morton compelled inhalation in spite of indications to arrest it, incurred the responsibility of doing so, and is entitled to the credit. . . . . A patient was, in fact, in great danger from over-inebriation at the first private operation. He was inhaling, in the continuous way that was at first supposed to be essential to protracted insensibility, through a glass globe of ether, and long after insensibility was manifested. The operation was far from completed when a bystander happened to feel the pulse. There was no special reason for doubt, inasmuch as the patient was, in general appearance, like all former thoroughly-etherized patients. The pulse proved to be barely perceptible, and the patient to be etherized almost beyond recovery. The bystander, after repeated observation of other cases, published the fact, then first observed, that in ether anæsthesia the pulse stood as a beacon between safety and danger, between harmless inebriation and fatal narcotism. This was the discovery that ether was not dangerous, because this showed that its danger gives warning and is under control. The operator was Dr. Dix, the bystander myself, and the discoverer Morton. To his impetuous, unremitting, reckless experimentation to establish anæsthesia, surgeon, bystander, patient, ether, and apparatus were all for the time and in that relation subordinated. Morton had asked me to be present because I was more familiar with the new process than anybody except himself, and for the purpose of aiding him in emergency with professional advice. But the anæsthesia was his: I assumed no responsibility. Had the patient died in a stupor, as he might well have done, Morton was liable; and as the patient did not die, his was the credit. This was real danger. But there was other danger, more startling, though only apparent, such as prostra-

tion, 'trance' or 'mania,' lasting for hours, and for which Morton was in one instance threatened with prosecution."[1]

Morton not only assumed these grave responsibilities in the interest of his discovery, but he sacrificed in its behalf all his time and all his means. From the first he was overwhelmed with correspondence upon the subject, and his personal services were in constant demand, and during the whole "ether controversy" he fought for his rights with a magnificent courage and unwearied persistency which must have extorted the admiration of his most determined opponents. He believed in his cause, and was from the first bold, determined, and aggressive in its defence. Through the daily press and through scientific journals, by correspondence with the learned societies both of Europe and America, he made his cause known. Before the various committees appointed by Congress to examine his claims he appeared, and the extent of the labors which these official investigations alone devolved upon him can be appreciated only by those who have examined the voluminous testimony produced, and know that his was the guiding mind which massed it for presentation.

The literature of this controversy fully disproves Dr. Jackson's assumption that Morton was an ignoramus and an imbecile, and makes clearly manifest the fact that he was a man of extraordinary force of character, and that the moral qualities he displayed in defence of his rights as a discoverer were precisely those needed to make his discovery possible.

Beneficence of the Discovery.—Concerning the boundless beneficence of the agency he invoked to steep the pangs of pain in sweet obliviousness all men agree. "It is probable," says Lecky,[2] "that the American inventor of the first anæsthetic has done more for the real happiness of mankind than all the moral philosophers from Socrates to Mill."

The venerable Dr. Warren, in the first flush of enthusiasm over the great discovery, exclaimed, "A new era has opened to the operating surgeon. His visitations in the most delicate parts are performed not only without the agonizing screams he has been accustomed to hear, but sometimes with a state of perfect insensibility, and occasionally even with the expression of pleasure, on the part of the patient. Who could have imagined that drawing the knife over the delicate skin of the face might produce a sensation of unmixed delight! that the turning and twisting of instruments in the most sensitive bladder might be accompanied by a beautiful dream! that the contorting of ankylosed joints should coexist with a celestial vision! If Ambrose Paré and Louis and Dessault and Cheselden and Hunter and Cooper could see what our eyes daily witness, how would they long to come among us and perform their exploits once more! And with what fresh vigor does the living surgeon, who is ready to resign the scalpel, grasp it and wish again to go through his career under the new auspices!"

Not only to Morton, but also to Wells and Jackson, the bitter controversies which grew out of this great invention brought discomfiture,

[1] *A History of the Discovery of Modern Anæsthesia*, by Prof. Henry J. Bigelow.
[2] *History of European Morals*, vol. i. p. 91.

ruin, and untimely death. Wells, becoming the victim of morbid illusions, and finally of violent mania, on January 14, 1848, ended his life with his own hands in a prison-cell in New York, where he had been consigned subsequent to arrest for acts of violence committed in the streets of that city; Jackson, after years of hopeless insanity, died August 28, 1880, in an asylum in Somerville, Mass.; and Morton, stricken with apoplexy, "induced by a publication in behalf of Jackson of a nature to prejudice a subscription then arranged in New York for his benefit" (Bigelow), there died, July 15, 1868, "poor in a cause which has made the world his debtor."

Ether.

Discovery.—This substance is supposed to have been known at least as early as the thirteenth century, as there is some evidence that its existence and leading physical properties were understood by Raymond Lully of Majorca, who flourished during that period. Basil Valentine also mentions a substance having a "subtle, penetrating, pleasant taste and an agreeable smell," which he obtained by the action of oil of vitriol upon alcohol.

The honor of the discovery of ether is, however, usually assigned to the German physician Valerius Cordus, who in the year 1540 described the method of making it and gave it the name of *oleum vitroli dulce.*

Investigations of Frobenius.—For nearly two hundred years following the publication of his formula by Valerius Cordus but little mention of the substance appears in chemical or medical writings; indeed, its mode of preparation had become almost a lost art at the time of Sigismund Augustus Frobenius, M. D., F. R. S., who in a paper read before the Royal Society of London in the year 1730 brought it prominently into notice. In this paper[1] he for the first time applied to the fluid the term "æther," and describes its physical properties as follows:

> "The æther of plants appears to be almost destitute of all gross air. . . . . A little of it poured on the surface of the hand affects it with a sense of cold equal to that from the contact of snow, and blow upon it but once or twice with your mouth, immediately your hand becomes dry. Beware, however, of approaching a lighted candle with your hand thus wet, lest it take fire and burn you. . . . .
>
> "Hence it appears that this æther is both fire and very fluid water, but so volatile that it soon evaporates, and that it is the purest fire, insomuch that if kindled in a thousand times the quantity of cold water, it burns inextinguishably." . . . . "The sense of touch does not manifest the least oiliness or fatness in this æthereal liquor, notwithstanding that it is the true, natural, and only dissolvent or menstruum of all fat, oil, rosin, and gum whatever."

November 18, 1731, Frobenius performed before the Royal Society certain experiments "with his *spiritus vini ætherens* and the phosphorus urinæ," from the recorded account of which the following is extracted:[2]

[1] "An Account of a *Spiritus Vini Æthereus*, with several experiments tried therewith," *Philosophical Transactions*, abridged, 1719–33, pp. 744, 745.

[2] *Phil. Trans.*, abridged, vol. ix. pp. 372, 373.

"He took a solution of phosphorus in the æthereal spirit of wine, which he called *liquor luminosus*, and poured it into a tub of warm water; whereupon it gave a blue flame and smoke, attended with so small a degree of heat as not to burn the hand if put into it.

"He poured some of his æthereal spirit of wine upon a tub of cold water, and set it on fire with the point of his sword, which being first heated a little, he touched with it a piece of phosphorus lodged beforehand on the side of the tub. After the deflagration the water was cold."

Frobenius then showed the now common experiment of burning phosphorus under a glass bell, producing a large quantity of *flores*.

"As the *flores* began to cover the inside of the bell to some considerable thickness, the flame was not seen through so brightly as before, but the whole appeared of a light azure or sky color, which the doctor likened to the formation of the firmament. The *flores* sublimed he likened to snow."

The formula followed by Frobenius in the preparation of ether was not publicly announced until after his death in 1741, when the secretary of the Royal Society, C. Mortimer, M. D., published the following statement concerning it:[1]

"Dr. Frobenius being dead, and some learned chemists in Paris, in Germany, and in Italy having endeavored in various manners and with different contrivances to make this ethereal spirit, I thought it would be acceptable to the curious in England to give them an abstract of the three papers the doctor communicated to the Royal Society concerning his *spiritus vini æthereus*. The first he gave in on Feb. 19, 1729–30, along with what is printed in vol. vii., but was desired by the author not to be published at that time. In this paper he says you must take of oil of vitriol and the highest rectified spirit of wine equal parts by weight, not by measure; that the oil of vitriol was to be poured by little and little into the spirit of wine, because they will grow hot upon mixing; that they should be shaken often, that they may mix thoroughly; then to be digested in a glass retort, and a large receiver to be applied and luted on, lest the subtil spirits should fly away; then distil them in an *athanor* in gentle digestion for three days, and pour back the distilled liquor till the liquor in the recipient appears double or of two sorts. Thus far, he says, Sir Isaac Newton was acquainted with the process. . . . .

"He concludes by telling us that the first part of the process, till one comes to the separation of the two liquors, is mentioned by Caneparius in his book *De Atramentis*, first printed at Venice, and afterward at London; then by the great Mr. Boyle, afterward by Sir I. Newton—that Dr. Stahl and Professor Hoffmann were the first in Germany who knew the first operation from Kunckel, but neither of them brought it to perfection or knew the effect of it. In France, M. Homberg undertook an experiment somewhat analogous to this with sulphur and oil.

"The second paper was communicated on the 12th of February, 1740–41, in Latin, and contains an ample account of the whole process, with improvements and additions; but as the author in his third paper, given in Feb. 19, 1740–41, in English, says that that is the truest and most advantageous process, I shall present it to the reader as follows:

"Take four pounds in weight of the best oil of vitriol, and as much in weight, not measure, of the best alcohol or the highest rectified spirit of wine.

[1] *Phil. Trans.*, 1732–44, vol. ix. pp. 379–381.

"1. First, pour the alcohol in a chosen glass retort; then pour in, by little and little, one ounce of oil of vitriol; then shake the retort till the two liquors are thoroughly mixed, when the retort will begin to grow warm; then pour in more of the spirit of vitriol, and shake it again; then the retort will become very hot. Do not pour in the spirit of vitriol too fast or too much at a time, lest the glass retort, by being heated too suddenly, should burst. You must allow about an hour's time for pouring in the spirit of vitriol, not pouring in above an ounce at a time, and always shaking the retort, till the whole quantity of the ponderous mineral spirit is intimately united with the light, inflammable vinous spirit.

"2. In the next place, examine with your hand the heat of the glass retort, and have a furnace ready, with the sand in the iron pot, heated exactly to the same degree as the retort has acquired by the mixture of the two liquors; take out some of the sand, and, having placed your retort in the middle of the iron pot, put in the hot sand again round the retort, and apply a capacious receiver to it; set it in cold water, and wrap it over with double flannel dipped in cold water.

"Raise your fire gradually, that the drops may fall so fast that you may count five or six between each, and that beside this quick discharge of the drops, the upper hemisphere of your receiver appear always filled with a white mist or fumes; continue this heat as long as they emit the scent of true marjoram.

"As soon as the smell changes to an acid, suffocating one, like that of brimstone, take out the fire, and lift the retort out of the sand, and change the receiver; for all that arises afterward is only a mere gas of brimstone, and of no use.

"If you do not use the greatest precaution the liquors in the retort will run over: the fire must cease as soon as the ethereal spirits are gone over, for there remains behind an *oleum vini*, which is extracted by the force of the acid out of the spirits, which will arise, run over, and often cause explosions.

"The second day, when your glass is cold, infuse the remainder with half as much alcohol, and distil again as before, and you will have the same. The third day again with as much, and proceed as at first: it gives it again. Go on as long as you can obtain any of the ethereal spirit, till all turns to a *carbo;* then separate it, and *alcalize* it with spirits of *salt armoniac* made without spirits of wine, till all effervescence ceases, and distil it once more è balneo marica; so is it ready for experiments."

Modern Chemical View.—The process of Frobenius has, of course, been much simplified and improved, but in all essential principles it remains unchanged. The view taken of the chemical changes upon which the production of ether is dependent has, however, with the progress of chemical science, undergone many important modifications, the theory now generally accepted being that of Williamson, that in the distillation of alcohol with sulphuric acid, acid ethyl-sulphate (sulphovinic acid), and water are first formed, as follows:

$$\underset{\text{Alcohol.}}{\left.\begin{matrix}C_2H_5\\H\end{matrix}\right\}O} + \underset{\text{Sulphuric acid.}}{\left.\begin{matrix}H\\H\end{matrix}\right\}SO_4} = \underset{\text{Acid ethyl-sulphate.}}{\left.\begin{matrix}C_2H_5\\H\end{matrix}\right\}SO_4} + \underset{\text{Water.}}{\left.\begin{matrix}H\\H\end{matrix}\right\}O.}$$

By the continued application of heat in the presence of an additional molecule of alcohol one molecule of ether (ethyl oxide) and one of sulphuric acid are evolved:

$$\underset{\text{Alcohol.}}{\left.\begin{matrix}C_2H_5\\H\end{matrix}\right\}O} + \underset{\text{Acid ethyl-sulphate.}}{\left.\begin{matrix}C_2H_5\\H\end{matrix}\right\}SO_4} = \underset{\text{Ether.}}{\left.\begin{matrix}C_2H_5\\C_2H_5\end{matrix}\right\}O} + \underset{\text{Sulphuric acid.}}{\left.\begin{matrix}H\\H\end{matrix}\right\}SO_4}.$$

The ether thus formed, owing to its superior volatility, passes out of the retort in the form of vapor to be condensed in the receiver, while the sulphuric acid remains ready to enter anew into combination with alcohol as in the first reaction.

Thus, theoretically, a given amount of sulphuric acid could be used indefinitely, but practically its power of etherification is limited to about six times its own weight of alcohol, the chief reason for its failure to act further being found in its dilution by the water formed in the process, and for which it has so great an affinity.

Preparation of Ether by Modern Processes.—To prepare pure ether by modern processes alcohol mixed with a given proportion of sulphuric acid is placed in a retort provided with a suitable condenser and raised to a temperature between 260° and 280° F. The ether distils over, contaminated, however, with a certain amount of alcohol, water, sulphurous acid, and various other products of secondary decomposition. For use as an anæsthetic all these impurities must be carefully removed, for although so commonly known as sulphuric ether, a pure specimen contains no trace either of that or any other acid, the term "sulphuric" being simply in allusion to the acid employed in its preparation.

To effect the necessary purification of the crude distillate it is first agitated with distilled water, which unites with any alcohol present. After a certain length of time the ether will nearly all separate from the water and float upon its surface. It is then carefully poured off, and shaken up in a closely-sealed vessel with lime and chloride of calcium; these free the ether from any remaining traces of water and alcohol and from all acid contaminations. Finally, the ether is subjected to a second distillation. Thus prepared, it constitutes the *æther fortior*, or stronger ether, of the United States Pharmacopœia, the standard of which is a specific gravity not greater than 0.728. It is a colorless, limpid fluid with a characteristic odor, fragrant and penetrating in its quality, and a sweet and pungent taste.

Ether is a solvent of phosphorus, sulphur, iodine, bromine, bromoform, iodoform (sparingly), chloroform, alcohol, oils and fats, caoutchouc, and gutta-percha: it is itself soluble to a limited extent (five parts in fifty) in water.

For inhalation the stronger ether must be employed. Usually, the practitioner can rely upon the drug as sold by responsible firms, but in cases of doubt the specimen should be carefully examined and tested.

Testing Ether.—In testing, a suitable hydrometer will give fairly reliable results as to specific gravity, absolute ether having at 68° F. a specific gravity of 0.710, the *æther fortior* that already indicated; anhydrous ether will not dissolve tannin.

For the freedom of the specimen from alcohol the following test is given in the *Pharmaceutical Proceedings* for 1871–72: it is to add to the ether a small amount of pyroxylin; if this, after standing a few minutes, be not dissolved, the absence of alcohol may be inferred, the

presence of a certain proportion of alcohol being essential to the solution of pyroxylin in ether. Crystals of fuchsin will produce a red color with alcohol if it be present in the suspected specimen of ether, while the latter, if pure, will remain colorless.

All acid contaminations may readily be detected, as they redden blue litmus. The sulphur acids, which are those most likely to be present, produce a white precipitate with barium chloride or nitrate. Acetic acid develops a red color with a salt of iron.

If the stronger ether be shaken with an equal bulk of water, it loses from one-tenth to one-eighth its volume. It boils actively in a test-tube half filled with it, and enclosed in the hand, on the addition of small pieces of glass. Half a fluidounce of the liquid, evaporated from a porcelain plate by causing it to flow to and fro over the surface, yields a faintly aromatic odor as the last portions pass off, and leaves the surface without taste or smell, but covered with a deposit of moisture (*U. S.*). The absence of odor in this test is well adapted to establish the freedom of the specimen from fusel oil.

Chemical and Physical Properties.—Ether is an exceedingly inflammable substance, and in the pure state becomes gaseous above the temperature of 95° F. Although so rapidly volatilized, the vapor has a density more than twice as great as that of atmospheric air, so that during its administration by inhalation large volumes of the vapor will sink to the level of the floor, and there remain until diffused in the general air of the room—a result which, owing to the great tension of the vapor, speedily follows. As the vapor is inflammable, and when mixed with air very explosive, lighted lamps and all incandescent substances should, if used at all during etherization, be kept above the level of the patient and operator. Even in pouring ether from one bottle into another caution should be observed, the close proximity of artificial light being dangerous.

Physiological Effects Internally Administered.—The effects of ether internally administered are in most respects analogous to those produced by alcohol. The degree of local irritation which results will, as with alcohol, vary with the amount and purity of the drug. When swallowed without dilution the lining membrane of the stomach becomes congested; there is stimulation of the gastric follicles and an increased outpouring of all digestive fluids, including the saliva. As, however, the digestive ferments are rendered inert through precipitation of their albuminoid constituents, the digestive process is for the time arrested, and chronic etherism, like chronic alcoholism, results in structural degeneracy of the digestive organs and permanent impairment of their functional power.

Owing to the rapidity of its vaporization at the body temperature, the burning sensation which ether at first produces in the mouth, throat, and stomach is speedily succeeded by a sense of coolness. The tension of the vapor and the rapidity with which it is formed usually cause copious eructations, and frequently occasion painful gastric distension. As at low temperatures vaporization goes on less rapidly, it has been recommended that the ether be taken mixed with ice-cold water. Anstic took two and a half fluidrachms of ether suspended in

six ounces of a mucilaginous mixture, and, owing to the protective action of the vehicle, with no more uncomfortable local result than a considerable heat at the pit of the stomach. As with alcohol, however, habitual use results in a certain degree of tolerance, and persons addicted to the ether habit ingest even as much as a fluidounce of the substance not only without discomfort, but with apparent enjoyment. The use of ether as an intoxicant is said to have been at one time much in vogue in the north of Ireland.

Like alcohol, ether is a cerebral sedative, but owing to the rapidity with which it is eliminated from the system (chiefly by the lungs), the entire duration of its influence as an intoxicant is, as compared with alcohol, quite limited, usually not exceeding one or two hours. During the period of intoxication the action of the heart becomes intensified; a pleasurable glow, followed by diaphoresis, is felt over the entire cutaneous surface; the face is flushed, the eyes brighten, all the senses are quickened; a disposition to muscular movement is manifested—this, chiefly in accordance with the disposition of the subject, varying in character from mere restlessness to inco-ordination or maniacal violence. The mental perversions usual to the condition of drunkenness speedily appear; ideas become confused and distorted, and speech disjointed, rambling, and incoherent, all ending at last in mere obliviousness, with complete suspension of the intellectual functions and with a greater or less degree of paralysis of the motor and sensory nervous tracts. In all cases the body temperature, at first elevated, becomes reduced, and the reduction will continue during that period of lassitude which follows as the necessary reaction from over-stimulation.

Two drachms and a half of ether, taken by Anstie at 10.35 P. M., had at 10.50 P. M. produced a full, bounding pulse, 104 beats to the minute. "There was decided giddiness, great heat and flushing of the face, and perspiration on the brow; the lips also felt stiff, and there was a pricking sensation in them; the sense of the heart's action was painful, as in an attack of palpitation. The mental condition was one of slight confusion. At 12.30 this feeling of giddiness and confusion had hardly disappeared; pulse 96." At 8 A. M. on the following morning he awoke with headache and nausea, which soon passed off.[1]

From this it would appear that between two and three drachms of ether will produce mildly narcotic effects in an adult. A much smaller amount would doubtless produce a decided influence upon persons of great susceptibility or upon those entirely unaccustomed to the use of stimulants.

As proved by the experiments of Anstie, the constitutional effects of ether may be obtained by its absorption through serous as well as mucous surfaces. The injection of half an ounce of ether into the peritoneal cavity of a large terrier resulted in muscular paralysis of the hind quarters and complete loss of sensibility, while full anæsthesia was obtained from the injection of fifty minims of ether into the peritoneal cavity of a large rat. By the immersion of cutaneous surfaces in ether a certain degree of narcotism may be developed, although this is chiefly local in character, owing to the extreme slowness with which absorption

[1] Anstie on *Stimulants and Narcotics*, p. 332.

into the circulation goes on as compared with rapidity of elimination through the respiratory and other tracts. By direct contact of ether with nerve-tissue a suspension of its functions may be secured. In case the nervous tract experimented upon contains both motor and sensory filaments, the functional power of the latter will first be interfered with; motor paralysis will occur subsequently.

Physiological Effects by Inhalation.—Passing now to the inhalation of ether vapor through the respiratory tract, it will be found that the physiological effects produced by this method of administration differ only in minor details from those just described.

The earliest impressions made by the vapor are upon the olfactory and gustatory senses, these impressions being to most persons disagreeable in character. The taste developed is usually pungent and somewhat bitter, although some observers ascribe to it a fruity sweetness of quality which, in the writer's experience, pertains more to chloroform. As the rapidly-vaporized ether particles impinge upon the mucous lining of the mouth and fauces the temperature of the parts is decidedly lowered, and a sense of cold is communicated to the nerves of common sensation distributed to them.

The functional activity of the salivary glands is increased—a result probably chiefly due to the local action of the ether vapor; although it is claimed by Anstie that he has observed the same effect in many mammalian animals, not only when the anæsthetic has been inhaled, but also when it has been injected into the peritoneal cavity, the rectum, or the stomach. The increased salivary flow is by him regarded as due solely to sympathetic paralysis; but more recent investigation shows that in addition to increased blood-pressure resulting from vaso-motor paresis there is direct stimulation of the secretory nerves of the gland.

Upon partial vaso-motor paresis, too, depends flushing of the face and increased diaphoresis; which effects are produced early in the progress of etherization.

Contact of ether vapor with the walls of the pharynx and the highly-sensitive laryngeal mucous surfaces often proves irritative, and, an impression being thus made upon the superior laryngeal nerve, and by reflex action upon the pectoral and abdominal expiratory muscles, the act of coughing ensues, this movement being often still further incited by a profuse mucous outflow, the result of local hyperæmia and direct stimulation of the mucous follicles of the respiratory tract. These irritative causes also frequently excite to functional activity those sensory and motor filaments of the pneumogastric controlling the act of deglutition, and repeated attempts at swallowing will be made. Fortunately, the power to swallow is usually very persistent, and even when the patient is fully narcotized it is not uncommon to see the act of swallowing automatically performed and the mouth and fauces thus relieved of fluid accumulations.

Sometimes, owing to these reflex irritations, the muscular apparatus concerned in the act of vomiting will be put in operation and an effort be made to void the contents of the stomach.

The violence of these local effects will vary with the nervous susceptibility of the individual; it is also, to a certain extent, dependent upon

the degree to which the air is saturated with ether vapor in the earlier stages of the anæsthetic procedure. If the volume of vapor be too highly concentrated, to the exclusion of a due proportion of atmospheric air, a suffocative feeling too will be developed in consequence of the need of the system for more oxygen.

The earlier stages of ether narcosis are marked by a decided increase in the pulse-rate and in the frequency of the respiratory movement, these results being speedily followed by depression to or below the normal standard. The following table, from Anstie, gives the average effects upon these functions in thirty-four cases, twenty-one males and thirteen females, all but three being over the age of puberty, and all free from any discoverable disease of heart or lungs:

	At commencement of inhalation.	At end of first minute.	At end of second minute.	At end of third minute.	At end of fourth minute.	At end of fifth minute.
Average frequency of pulse	74.5	92.7	109.8	110.2	94.3	69.3
Average frequency of respiration . . .	23.0	23.0	24.7	26.3	18.9	15.67

The high average rate of respiration which, as this table shows, was manifested at the commencement of inhalation is explained by Anstie as being due to agitation and alarm on the part of some of the subjects of the experiments—a very usual condition, especially with females. It will be observed that while the rise and fall in pulse-rate and the rate of respiration are coincident, these respective movements are not by any means in the same numerical ratio, the range of increase and decrease in the number of heart-beats being relatively much the greater of the two.

These changes, associated as they are with other functional disturbances kindred in character, have caused a general recognition of the fact that the phenomena of anæsthesia are divisible into two clearly-defined stages—a stage of excitement and a stage of depression.

Effects on the Nervous Centres.—As the inception and progress of these effects are necessarily associated with impressions communicated to the nervous organism, the nature, extent, and sequence of the functional changes there excited will now be considered.

Flourens was among the first to describe them: his view was that the great nerve-centres are narcotized in the following order and with the following results: First, the cerebrum, resulting in loss of intelligence and consciousness; second, the cerebellum, with loss of its power of "equilibration" or co-ordination of movement; third, the spinal cord, with loss of its power of receiving sensory impressions and of initiating movements; fourth, the medulla oblongata, with paralysis of the respiratory and circulatory functions.[1]

[1] See *Comptes rendus de l'Académie des Sciences*, séances des 8, 22 février et 8 mars, 1847, t. xxiv. pp. 161, 253, 340.

The theory promulgated thus early in the history of anæsthesia has not been materially modified by the observations of subsequent experimenters, except in so far as relates to the operation of anæsthetic agents upon the sympathetic nervous system, concerning the structure and functions of which so much light has been gained through the labors of later physiologists.

Anstie was the first to call attention to the fact that the sympathetic nervous system is the earliest to feel the influence of the anæsthetic, this being indicated by the flushing of the face, increased salivary secretion, etc., already alluded to. But while it is the first to receive the impression, it is the last to succumb to the narcotic power of the agent employed, so that even after paralysis of the medulla oblongata, and consequent cessation of the respiratory act and of perceptible movement of the heart, certain processes of vegetative life, such as intestinal movement, arterial contraction, etc., over which the sympathetic presides, may still go on. It would, then, appear that its partial paralysis is the first, and its complete paralysis the last, in the sequence of effects set up in the nervous system by ether and other allied drugs.

Nature of Ether Narcosis.—Anstie's peculiar views in regard to narcotism led him to reject the idea that stimulation, in the common acceptation of the term, has any part in ether narcosis, he claiming that rapidity of movement in heart and lungs is an evidence not of strength, but of weakness—a conclusion not confirmed by the later developments made by the sphygmograph and other instruments of precision. While the physiology of the subject is not by any means definitely determined, a rational explanation of the known phenomena would seem to be that the ether vapor, entering the circulation through the walls of the capillary blood-vessels which surround the pulmonary vesicles, produces, primarily, by contact, a partial local paralysis of the vaso-motor branches of the sympathetic system distributed to the walls of the pulmonary vein. The tonicity of its walls being thus diminished, an increased amount of blood is admitted through it to the left ventricle of the heart, whence a portion enters the coronary arteries to pass directly into the substance of the heart itself. As the ether-laden blood enters the coronary arteries their vaso-motor nerve-fibres also undergo partial paralysis, and their walls a loss of resisting power to the impact of the vital current, so that the muscular fibres of the heart and its motor ganglia receive the stimulus of an increased supply of blood; under which stimulus it is for a time incited to greater activity. As its pulsations increase in force and frequency larger amounts of blood are sent through blood-vessels—which, in their turn, become dilated—to all the great vital centres and to all organs and tissues of the body, their functional power, in consequence of such increased stimulation, undergoing for a brief period a greater or less degree of exaltation.

Such are really Nature's agencies for hurrying through the system and expelling through her eliminative organs and tissues the offending agent. And in the case of so volatile a substance as ether these means would be ample for the purpose were the administration of the drug at once suspended: then the stage of general depression, except as the result of the usual reaction after stimulation, would not be reached;

but as increased volumes of ether vapor continue to pour into the circulation, its very rapidity of movement becomes tributary to the power of the toxic agent. Elimination cannot keep pace with supply. The pulse and respiration diminish in force and frequency; the great ganglionic centres of the nervous system begin to yield; the very citadel of life totters, and will fall unless the invading forces be held in check or withdrawn.

Phenomena of Etherization.—It is evident that the minor physiological effects already described as incident to ether narcosis are directly dependent upon these functional disturbances in the respiratory, circulatory, and nervous systems. This is equally true of those now about to be considered.

As the result of an increased supply of blood to the brain there is a momentary stimulation of the intellectual functions: ideas as they are formed are not always coherent, but they are developed with greater rapidity than in the normal state, and are dominated by a pleasurable exhilaration. These effects are, however, soon followed by giddiness, a tumultuous rush of undefined impressions, ending in unconsciousness; which latter condition comes on at a very early period after the full inhalation of ether begins.

Preceding the loss of consciousness a sense of warmth, due to the rapidity of the circulation and to the capillary hyperæmia, will be perceived. This is soon followed by a faint numbness and tingling, caused by the partial paralysis of the superficial sentient nerves, these being among the earliest indications of approaching anæsthesia. As the motor nerves do not yield so readily to the narcotic influence, muscular movement is still stimulated, and, although lacking co-ordination, is frequently quite active, and generally directed to an avoidance of the anæsthetic or to an effort to combat the physical restraint exercised by the operator. After the loss of consciousness it often takes on a more violent form and becomes convulsive or tetanic in character. This form of muscular movement is most pronounced in male adults, especially those in whom the muscular system is strongly developed as the result of labor or exercise. Dr. Snow states that the patient in whom, in his experience, these symptoms were most violent was a celebrated harlequin attached to one of the London theatres. The cessation of these movements and the complete relaxation of the muscular system mark the stage of complete narcosis, in which, not only intellection but movement and sensation are suspended.

Effects on the Eye.—The ordinary effects of anæsthetics upon the eye are somewhat variable. At the very beginning of the administration of the anæsthetic, or even before, the pupil of the eye will be frequently found dilated. This dilatation, however, with advancing narcosis disappears, and the pupil at the same time manifests a greater or less degree of insensibility to light, so that it contracts very slowly when the eyelid is lifted for purposes of examination. At this time, too, the eyeballs will be found slightly divergent and turned upward to a considerable degree. Notwithstanding this condition of impassivity of the pupil under the stimulus of light, it gradually contracts, and so remains except in extreme narcosis, when there is a condition of slow dilatation,

the degree of myosis depending upon the extent to which the narcotic influence has been carried. With the removal of the anæsthetic the pupil gradually returns to its normal state, but during its return is subject to secondary dilatations.

An explanation of the precise physiological significance of these movements must of course be offered, subject to the same incertitude which still clouds the mechanism of the movements of the iris in the normal state. Upon this point the view most generally accepted is, that narrowing of the pupil is due to the contraction of the circular muscular fibres, or sphincter, of the iris which directly surround the pupillary orifice, this muscle being under control of the cerebro-spinal system through the oculo-motor nerve. Stimulation of this nerve, through its normal reflexes or otherwise, produces contraction of the sphincter, and consequent narrowing of the orifice of the pupil. Paralysis of the nerve produces an opposite condition.

The existence of radiating muscular fibres is now generally admitted by anatomists, their contraction directly antagonizing that of the circular muscular fibres, and they being under control of the dilating branches of the sympathetic contained in the long ciliary nerves. The sympathetic may, then, be regarded as furnishing the dilating, the cerebro-spinal system the contracting, nerve-force of the pupil.

The theory of Raehlmann and Witkowsky[1] concerning the nature of the pupillary changes which occur during anæsthesia is based upon their own observations, as well as upon the experimentations of earlier and contemporaneous physiologists, and is, that dilatation of the pupil is not alone dependent upon the influence of light and the movements of accommodation, but that it may be the result of psychic influences or follow certain sensory impressions made from without; which impressions, communicated to the brain, and thence to the medulla oblongata, and from there to the sympathetic nerve-fibres of the iris, produce, through contraction of its radiating muscular fibres, the effect in question.

To this sequence of influences may be attributed the dilatation observed before the inhalation of the anæsthetic begins, the psychical impression upon the brain of the patient being that of dread of the anæsthetic process or of the impending operation; in other words, the pupil dilates through fear.

Or when inhalation has begun the sympathetic may be influenced through the irritant effect of the ether vapor upon the nerves of special or general sensation distributed to the respiratory tract. It is of course evident that as the brain and sensory nerves, which are speedily anæsthetized, become incapable of receiving and communicating these psychic or sensory impressions, the sympathetic ceases to be influenced by them, and the motor oculi resumes its sway.

The insensibility to light exhibited by the iris during anæsthesia is, of course, due to partial paralysis of the motor oculi, which for this reason responds but slowly to the stimulus it ordinarily would receive, and does receive, through the optic nerve until the functions of the latter, too, are suspended.

[1] See Kappeler, *Anæsthetica*, pp. 59, 60, Stuttgart, 1880.

As with advancing narcosis paralysis of the motor oculi deepens, the sympathetic—which, as has been seen, retains a measure of functional activity after the reflex irritability of the cerebro-spinal system has been obliterated—continues to operate upon the dilator muscles with a power greater proportionately than the resistance of the constrictors, pupillary expansion being the result.

Returning consciousness brings with it a reversal of these phenomena. As paralysis of the motor oculi diminishes, its power of producing pupillary contraction is resumed, although this power is often antagonized by reflex action upon the ciliary or dilator branches of the sympathetic from a brain again aroused to consciousness and capable of influencing the sympathetic system with the impressions, generally painful, which attend the awakening from an anæsthetic sleep produced for surgical purposes.

Effects on Temperature.—Although at the beginning of etherization there is a slight temporary increase in surface temperature, caused by the turgescence of the cutaneous capillaries, the actual body heat is lowered very shortly after the inhalation of the anæsthetic begins. This is due to the retardation of tissue-changes consequent upon the presence of the anæsthetic in the blood and the diminished amount of oxygen admitted to the circulation.

In the carefully conducted experiments of Kappeler[1] upon twenty cases the minimum fall in temperature, as indicated by a thermometer fixed and retained in the rectum, amounted to 0.3°, the maximum to 1.5°, and the mean to 0.68° C.; or, excluding from the calculation those cases, eight in number, in which there was an abnormal temperature as the result of fever at the beginning of the experiment, an average fall in temperature of 0.52° C. was observed. In only three cases was there a slight increase (0.1° to 0.2°) of body heat at the beginning of inhalation, this increase being in each case associated with strong muscular movements. In thirteen cases the body temperature reached its original height during the course of the same day, while in seven cases, although there was an increase from the lowest point reached during inhalation, the temperature failed to attain its original height for a period varying from an hour and forty minutes to six hours and a half after the inhalation of the ether ceased. The fall in temperature began in thirteen cases ten minutes, in five cases fifteen minutes, and in one case twenty minutes after the commencement of inhalation. In one case this point was not noticed. Without exception the greatest depression in temperature was observed in those cases in which the ether had been exhibited in largest quantity and in which the deepest narcosis had been produced.

Stages of Anæsthesia.—Various authors have endeavored to group these physiological effects into a series of progressive degrees or stages of narcotism. Dr. Snow, one of the earliest writers upon the subject, made four degrees,[2] the first degree ending with loss of perfect consciousness; the second degree ending with complete loss of consciousness; the third degree terminating with the cessation of muscular spasm and all voluntary movement; the fourth degree being marked by com-

[1] Kappeler, *Anæsthetica*, pp. 168, 169.

[2] Snow on *Anæsthetics*, p. 37.

plete muscular relaxation and loss of sensibility. Sansom[1] makes three stages, as follows: "A *first stage*, SOPOR (perversion of sensibility); a *second stage*, STUPOR (abolition of sensibility); a *third stage*, STERTOR (muscular relaxation)." Kappeler[2] makes two stages: first, a stage in which consciousness is retained; second, a stage in which consciousness is lost—the first stage embracing simply aberrations in the domain of the special senses, disturbance of the intelligence, diminution of general sensibility and of the perception of pain, widening of the pupils, quickening of the movements of the heart, and irregularity of the movements of respiration; the second stage embracing all subsequent phenomena up to the complete loss of sensibility.

From this brief review of the few among many schemes of classification it is evident that although the phenomena of anæsthesia follow each other in certain apparent sequences, these are so involved, the one within the other, that it is not easy to define their beginning or their end. The fact, however, is apparent that the most significant and clearly-defined phenomenon associated with the inception of the anæsthetic influence is that of universal functional excitation, this being quickly followed by the partial obtunding of sensation and by suspension of conscious cerebration, excitation of the motor system still for a time continuing; and that at the end of the chain of effects is universal functional depression, with continuance of unconsciousness, and complete abolition of sensation. All intermediate or succeeding phenomena are associated with one or the other of these conditions, and, logically, must be classified with them.

From this point of view there are but two stages in anæsthesia: First, the stage of functional excitation, during the progress of which sensation is gradually obtunded and consciousness lost, this stage fully terminating only with the cessation of muscular spasm or rigidity; second, the stage of functional depression, in which the voluntary muscular system is relaxed and sensation abolished.

For convenience of description, however, the author prefers the classification of T. Lauder Brunton, who divides the action of anæsthetics into four stages, as follows:

1st. The stimulant stage;
2d. The narcotic and anodyne stage;
3d. The anæsthetic stage;
4th. The paralytic stage.

Narcosis carried only to the second stage of this classification is for anæsthetic purposes incomplete; narcosis carried to the fourth stage is excessive; and, as will be seen, either insufficiency or excess is in surgical operations dangerous.

CONDITIONS CONTRAINDICATING THE USE OF ANÆSTHETICS.

In all cases the patient should be subjected to a careful physical examination before being permitted to inhale the anæsthetic, because, while there are few conditions which absolutely interdict the use of ether, assuming that surgical interference is necessary, there are many

[1] *Chloroform, its Action and Administration*, p. 199.

[2] *Anæsthetica*, p. 42.

which, if known, would make obligatory upon the operator the exercise of a more than usual amount of care.

Ether is contraindicated in cases of cerebral congestion or where the existence of tumors or abscesses in the brain is known or suspected. In cases of extreme fatty degeneration of the heart ether should be given with great caution, and the same is true, although not to the same degree, where disease of the cardiac valves exists. The chief toxic force of ether is expended not so much upon the heart as upon the respiration; and all conditions of the lungs or air-passages obstructive of the respiratory function increase the liability to dangerous complications during the inhalation of ether vapor. For this reason the existence of acute bronchitis would be an unfavorable condition, as well as for the reason that the inflammation would probably be intensified by it. So, too, emphysema of the lungs, œdema of the glottis, and enlargement of the tonsils are sources of danger during anæsthesia just to the degree that they interfere with normal respiration. Given a patient already in a condition of partial asphyxia from either of these causes, and it would be hardly permissible that his supply of oxygen should be still further curtailed by substituting ether vapor for atmospheric air.

In the cancerous diathesis there seems to be a more than average danger attending the use of ether, and no inconsiderable percentage of the recorded fatalities under etherization have been in cases in which the operation required was for the removal of cancerous growths. Structural degeneracy of the kidneys, too, as in Bright's disease, has been found a condition peculiarly unfavorable for the administration of ether.

Shock.—The existence of that peculiar depression of the vital powers known as "shock," which so often follows the infliction of severe injuries, is by many surgeons regarded as contraindicating the use of anæsthetics, and where immediate operative interference is not demanded by the nature of the injury there can be no question as to the advisability of delay until reaction has occurred; but in many instances the pain arising from the presence of lacerated tissues, as in a crushed and partially severed limb, would of itself cause a persistence of shock, and make an immediate operation imperative; as, too, would persistent hemorrhage not to be controlled without the use of the knife. Ashhurst[1] advises that under such circumstances an operation should not be performed if the temperature of the patient has fallen below 96° F. If, however, the operation is the patient's only chance for life, even this evidence of extreme depression would hardly justify the surgeon in withholding his aid, however great the danger of death under the knife, and however reluctant he may be to assume the possible odium of such a misadventure. Assuming that under these conditions surgical interference is to be resorted to, the patient's chances of survival would be decidedly promoted by the use of ether; without it the renewed injury to tissue and the pain of the operation would intensify shock; with it, not only is pain prevented, but frequently the stimulant effect of the ether vapor sets up a process of reaction, and thus directly contributes to the patient's safety. The statistics presented

[1] *The Principles and Practice of Surgery*, p. 138.

by Sir J. Y. Simpson[1] show that amputation of the thigh performed in some of the leading hospitals of Europe before the introduction of anæsthetics was followed by an average mortality of 44 per cent., while the same operation performed upon anæsthetized patients was attended by a mortality of only 25 per cent.

Operations upon the teeth and associated tissues are often excruciatingly—and in certain conditions of the system dangerously—painful in character. That fatal results may follow such operations in consequence of reflex impressions made through the fifth nerve upon vital ganglia is a well-established fact. A formative alveolar abscess, with its train of possible complications, such as pyæmia, erysipelas, maxillary necrosis, trismus, etc., may occur in patients whose physical condition is such that they are neither fitted to endure the suffering incident to the full evolution even of the normal process of suppuration and discharge, nor able, without an anæsthetic, to bear the shock of such surgical measures as may be required to bring those processes to an earlier and perhaps safer termination. To these and all analogous conditions the general principles just set forth are fully applicable. When, however, in cases not favorable for the use of anæsthetics the necessity for a severe dental operation can for the time be postponed by the use of palliative measures, that course should by all means be adopted. This is especially true in cases of advanced pregnancy. The possible oxytoxic effect of any anæsthetic agent must be borne in mind, and if practicable the operation be postponed until the pregnancy has terminated.

The methods of placing the patient safely under the anæsthetic influence, the physical manifestations by which the progress and safety of the procedure may be determined, and the means by which dangerous complications may be antagonized, now claim consideration.

The Anæsthetic Procedure.

Mode of Administering Ether.—Attention has already been called to the physical and chemical properties of this substance, and to the necessity for avoiding the use of an impure or imperfectly rectified article.

Inhalers.—In order that the ether as it volatilizes may be carried into the respiratory tract upon the inflowing air-currents, the use of some form of inhaler to hold the liquid and, in a measure, confine its vapor is imperative. As already stated, that originally used by Morton was a glass flask with a tube, this being subsequently modified by the addition of valves.

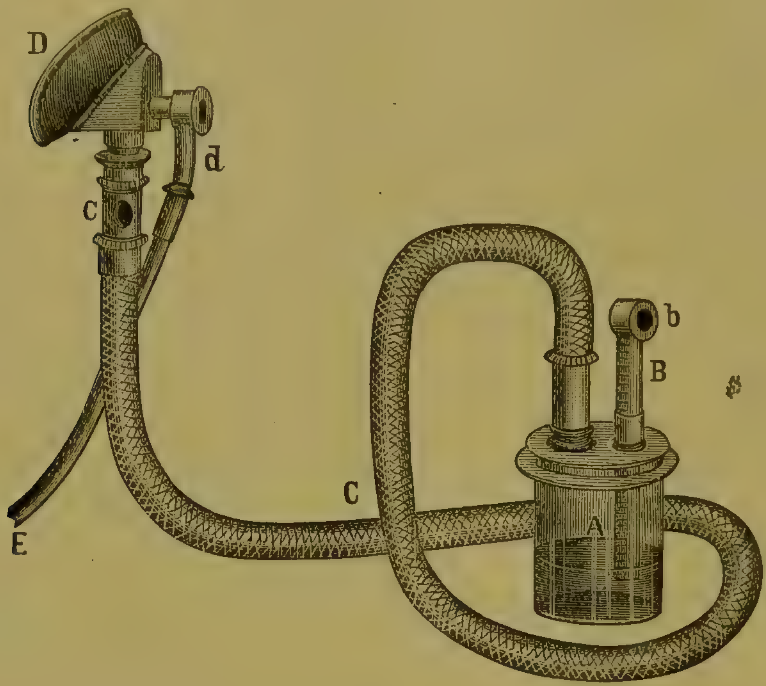
A form of inhaler somewhat allied to this in principle, although much modified in structure, is that of Hawksley, seen in Fig. 1. "It consists of a glass jar A, which will contain ten ounces of ether. The tube B, which contains a valve opening inward, is graduated in order to measure the amount of ether used. The elastic tube C connects the ether jar, A, with the mouthpiece D, and has near the latter a sliding valve (C) for the dilution of the ether vapor with atmospheric air. An

[1] *Anæsthesia*, p. 105.

expiration valve (d) and the tube E conduct the expired air out of the proximity of the operator."

Such forms of apparatus are, however, all unnecessarily complicated; valves, tubes, and mouthpieces are difficult to keep clean, and are con-

FIG. 1.



stantly liable to derangement. Inhalers which entirely dispense with these adjuncts are much to be preferred. One much favored by many is that of Dr. Allis (Fig. 2). It consists of an open framework arranged

FIG. 2.

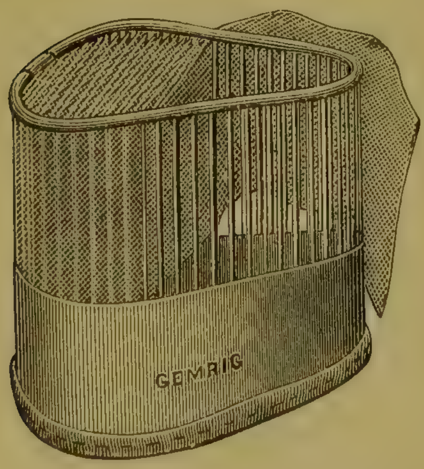


FIG. 3.

to support strips of muslin placed at short distances apart, upon which strips the ether is continuously dropped until anæsthesia is produced. This inhaler is eminently safe, inasmuch as it permits of the fullest possible admixture of air with the ether vapor. It is, however, a somewhat wasteful instrument, as in order to charge such large vol-

umes of air with sufficient ether vapor to produce full anæsthesia it is necessary to use large amounts of the drug.

The inhaler of Dr. Barr (Fig. 3) is not open to this objection. It consists of an open framework made very much after the manner of an umbrella frame. The framework is covered with impermeable rubber cloth, and its interior is lined with a cone of Canton flannel, which may be readily removed when soiled. The ether is dropped into a small funnel placed at the top of the frame: from the funnel the ether passes by a tube to the interior of the inhaler, where it drops upon the Canton flannel lining, from whence it vaporizes.

The simplest form of inhaler, however, is the best. Such a one can be readily extemporized by making from a stiffly-starched towel a hollow cone, and placing in the interior a hollow sponge slightly moistened in warm water, upon which the ether may be poured; or a cone more impervious to the ether vapor may be made from a newspaper, a soft napkin or towel, in lieu of a sponge, being folded up with it on its inner surface. These extemporized inhalers have the advantage of convenience, as the materials for making them are always at hand, and of cleanliness, as after one using they may be discarded. Some surgeons, however, prefer a cone made of felt or leather and lined with a porous fabric for the imbibition of the liquid ether. However made, the base of the cone should be large enough to cover the mouth and nose, but should not be so closely adapted to the face as to exclude atmospheric air. The apex it is well to leave open.

Preparatory Treatment of the Patient.—In all cases in which a severe surgical operation is to be performed it is desirable that the patient should be placed in the best possible condition for the reception of the anæsthetic and for recovery from the effects of the operation. Patients suffering from diseases of malnutrition, anæmic subjects, and those weakened by the effects of scrofula, syphilis, cancer, or other of the cachexiæ, should, when time permits, receive careful nutritive treatment, such articles of food being given as are most nutritious and most easily assimilated, and such medicines being administered as are restorative in character and directly promotive of constructive metamorphosis. By thus building up the system and strengthening the vital powers of the patient previous to the operation he will be much better fitted to endure its severities. In any case violent depletory measures are not to be thought of. While it is always desirable that the bowels should not be loaded with fecal matter, harsh purgation is not needed: a gentle laxative is all that is usually required, this, possibly, to be assisted by a purgative enema. By the use of such agencies the extreme depression so often following the use of violent cathartics will be avoided. The purgative selected should be given so that its full effect will have been accomplished four or five hours before the intended operation. In operating upon the rectum, however, surgeons usually prefer, in addition to a full purgation, to give a purgative enema about an hour before operating. The bladder, too, should be empty or nearly so, and the stomach should contain no food, solid or liquid. To this end the patient should not partake of food for at least four or five hours before the time appointed for the administration of the anæsthetic, and, as under

the influence of the mental emotions excited by apprehensions of the approaching ordeal the digestive process is often seriously retarded, it is advisable that very hearty food, such as solid meats, cheese, hard-boiled eggs, and the coarser vegetables, should be avoided during the twenty-four hours preceding the operation. Unless these precautions are observed there is danger that undigested food in the stomach, being ejected during the vomiting which so frequently occurs in the earlier stages of anæsthesia, may at the moment of ejection be drawn into the trachea by one of the violent inspiratory efforts usually following emesis, and so fatal strangulation follow—a result quite certain to ensue if anæsthesia has advanced sufficiently far to suspend the action of those reflexes through which in the normal state the foreign substances might have been expelled from the respiratory passages. For analogous reasons artificial plates and all other foreign bodies should be removed from the mouth.

Abstinence from food is required, not only for the reason here given, but because the presence of food in the stomach, and its consequent distension, necessarily encroach upon the thoracic cavity, and thus interfere with that highest possible freedom of respiratory movement so essential to the safety of the anæsthetic state.

Dr. Agnew has called attention to the fact that the rule here laid down is doubly imperative where an operation is to be attempted for the relief of ankylosis of the lower jaw. He says:[1] "I have seen a person from inattention to this point wellnigh perish by reason of the surgeon's inability to get anything into the mouth to clear out the pharynx, which had become obstructed by material rejected by the stomach while under ether."

The deprivation of food here insisted upon is not inconsistent with those measures for the promotion of nutrition previously recommended: four or five hours is not an undue interval between meals; and the fact must be borne in mind that it is not the undigested food in the stomach, but that which has undergone digestion and assimilation and has entered the circulation, which ministers to the nutrition of the patient and stimulates his vital energies.

Were it not for incidental inconveniences an early morning hour, before the patient has breakfasted, would be in the highest degree favorable for the anæsthetic process. The stomach is empty, but no faintness is experienced because the usual meal-time has not passed; refreshed by rest and sleep, the patient is at his best and without sufficient time for much brooding over the ordeal before him. Mr. Woodhouse Braine, a London "anæsthetist," recommends this hour, and states that Sir James Paget was in the habit of choosing it for his operations, and that he has "frequently met him far on the other side of London at 8 and 8.30 o'clock."[2]

Alcohol in Shock.—So far as the introduction of liquid substances into the stomach is concerned, the general rule is, in conditions of shock, often violated by the free administration of alcoholic stimulants but a short time previous to the beginning of the anæsthetic process; indeed,

[1] Agnew's *Surgery*, p. 282, vol. ii.
[2] *The Journal of the British Dental Association*, Dec., 1884.

many surgeons habitually adopt this practice in all cases in which there is any evidence of depression of the vital powers. Whatever may be the merits of, or necessity for, this practice, the fact must not be lost sight of that the presence of large amounts of alcoholic stimulants in the stomach—and in cases of shock they are often administered in inordinate amount and with unreasoning frequency—is subject to the same dangers pertaining to the presence of other substances. In the act of vomiting, fluids as well as solids may be drawn into the trachea, and cannot fail to embarrass the respiration to a serious extent, if not beyond all power of recovery. In all ordinary cases where ether is to be used the writer regards the giving of alcoholic stimulants as uncalled for, but in shock the administration of from half-ounce to ounce doses of whiskey or brandy is quite a general, although not a universal, practice. In the present state of our knowledge concerning the true nature of the vital depression in question, and of the rôle which alcohol really plays in the animal economy, the practice can hardly be said to rest upon other than an empirical basis, and a closer insight as to the physiological relations of the subject may very materially modify existing rules of practice. All that can at present be said with certainty is that in conditions of great depression alcohol produces a temporary excitation, which, if it is not the index of an absolute increase of vital energy, is at least an effect which closely simulates it. It may, however, be questioned whether this effect might not be more surely and safely obtained by other agents, such as ammonia, or by a cardiac stimulant, such as belladonna. This, however, will largely depend upon habit or constitutional peculiarity: in many cases brandy appears to be better borne by the stomach and to produce a more decided reaction than any other agent. Some practitioners have obtained excellent results from subcutaneous injections of ether; and very many habitually resort to hypodermic injections of morphia in doses of from a sixth to a quarter of a grain.

Maintaining Temperature in Shock.—Whatever method of medication may be resorted to, the temperature of the body must be maintained. This usually falls with the failure of the circulation incident to shock, and the tendency must be antagonized by friction or by sinapisms to the inside of the thighs, to the wrists, or to the chest and abdomen. The direct application of artificial heat should be resorted to. This can best be accomplished by placing bottles of hot water, heated bricks, etc. to the feet and other portions of the body, or by placing upon the chest and abdomen relays of flannel cloths wrung out of hot water. Rectal injections of water as hot as can be borne are also salutary, and the enemata can at the same time be made stimulant in character by the addition of brandy, ammonia, or turpentine.

Venesection.—Owing to the fact that in cases of death from shock the right side of the heart and the great venous trunks are found distended with blood, venesection has sometimes been resorted to, and with apparently beneficial effects. A writer on the subject[1] recommends that "in such cases the superficial veins of the neck should be examined, and if

[1] William Scovell Savory, F. R. S., in Holmes's *System of Surgery*, p. 154, vol. i.

distended the external jugular should be opened. This treatment," he says, "is sanctioned both by reason and experiment." Where large amounts of blood have already been lost as the result of surgical injury, this practice would certainly be inadmissible, and in the present state of public opinion as well as of professional sentiment concerning venesection he would be a bold man who would resort to such a procedure.

Preparation of the Patient.—Attention to the condition of the clothing is an essential part of the preparation of the patient for the inhalation of an anæsthetic. Under no circumstances should the wearing of garments which in the slightest degree impede the respiratory movements or at any point obstruct the circulation be permitted. Tightly-fitting shoes or garters should be removed, as they to a greater or less extent obstruct the venous circulation, and thus in a measure prevent the free return of the blood from the lower extremities to the heart. Collars should be removed, neckbands and waistbands loosened, and all garments covering the chest and abdomen be so arranged as to give full play to their normal movements during the respiratory act. Stays or corsets are, of course, entirely inadmissible, and any elaboration of toilet is in the highest degree objectionable. The garments worn either by males or females should be few in number and simple in character, so that in case of emergency they can be readily removed. In texture and weight they should be adapted to the season of the year and the temperature of the apartment, the importance of maintaining the bodily heat of the patient being always borne in mind.

Temperature of the Room.—The temperature of the apartment in which the anæsthetic is to be administered will have an important bearing upon the rapidity and completeness with which anæsthesia is attained, because, as has been shown by Snow,[1] the warmer the air the more rapidly will ether vaporize and the more perfectly will the air become saturated with the vaporous particles, so that too low a temperature is to be avoided, not only because it will reduce the bodily heat of the patient, but because it will interfere with the volatility of the anæsthetic. At 40° F. air will take up only 27 per cent. of ether vapor; at 60° F., 40 per cent.; at 70° F., 58 per cent.; and at 80° F., 71 per cent. These figures were obtained by Dr. Snow under conditions which permitted the full saturation of the air with ether vapor—conditions which rarely if ever occur in actual practice when the ordinary inhaling apparatus is used; but they clearly indicate the fact that in a room having a temperature so near the freezing-point as 40° F. very little ether would be evaporated, the anæsthesia being correspondingly imperfect, while at higher temperatures ether would be vaporized with great rapidity and the anæsthetic process be correspondingly rapid and effective. These theoretical deductions have been amply sustained by practical experience, and a temperature of from 70° to 75° F. may be regarded as the most favorable for the production of the anæsthetic state when ether is the agent employed.

It may be here remarked that not only should the room in which the anæsthetic is given be sufficiently warm, but a like care should be observed

[1] *Anæsthetics*, p. 347.

in regard to the room in which the patient is placed after the operation is completed.

Position of the Patient.—As a general rule, the patient should be placed in the supine position, with the head and shoulders but slightly raised, the head being in line with the long axis of the body and neither bent forward nor thrown backward. Braine[1] recommends "lying on the side, with one hand and forearm under the pillow, the shoulders being slightly raised and the neck a little bent, so that the saliva, which is always secreted in large quantities, may run from the lower corner of the mouth and not be swallowed." "This salivary secretion," he states, "readily takes up ether vapor, and if swallowed is sure to produce vomiting." While this position may be advantageous in certain cases, it somewhat cramps the respiratory movements, and the patient can breathe much more freely and deeply when placed upon his back as above described.

Recumbency in every practicable case should, however, be insisted on, so that as the heart-impulses weaken under the toxic influence of the anæsthetic the flow of the blood-currents to the brain and vital centres may be favored by gravity, and the circulatory apparatus be thus in a measure relieved from strain—a strain so great as sometimes to result in cardiac failure and collapse. This danger is not so imminent when ether is employed, and in operations in the mouth or upon the jaws the more convenient semi-recumbent position may sometimes be permissible; but when chloroform is used, so great is the danger of heart paralysis that full recumbency is imperative. The enormous percentage of deaths from chloroform in dental operations is doubtless largely due to neglect of this rule. With either agent it is a neglect for which there is no excuse. All modern dental chairs permit of the recumbent attitude on the part of the patient, and there is ordinarily in the position no insuperable mechanical obstacle to the extraction of the teeth: even if such an obstacle exists, the patient can readily be raised to the required posture at the moment of extraction, and then be as readily replaced in the recumbent attitude.

Assistants and Witnesses.—Ether should never be administered for surgical purposes without the presence of one or more assistants to the operator. The number required will vary with the nature and gravity of the operation and other attendant circumstances. In capital operations at least two assistants are usually required, one to control the circulation in the part to be operated upon, and one to administer the anæsthetic. This number is certainly desirable both for safety and convenience, although in emergencies, such as often arise during the progress of a war, the surgeon may be compelled to perform the most formidable operations without skilled aid. In dental practice the presence of an assistant or assistants is equally imperative—firstly, because when ether is used the patient may become restive and require the exercise of great physical strength for his restraint; secondly, because dangerous complications may arise demanding the immediate adoption of certain methods of treatment which the operator, unaided, would be unable to execute; and, thirdly, for the reason that the assistant is a witness to the

[1] *Op. cit.*

general conduct of the operation—a witness whose testimony would be invaluable were its regularity or skill called in question; and for the security of all concerned the presence of a third party, if not as an assistant, then as a witness, is indispensable. Especially imperative does this become when a female is to be anæsthetized. It is a physiological fact, now well established, that the nerves of special and general sensation in the genito-urinary tract are among the last to yield to the influence of anæsthetic agents, so that impressions made upon other portions of the nervous system are by the patient referred to these still sensitized surfaces, under which stimulus erotic dreams of a most vivid type are often the result: so vivid, indeed, are these impressions that the protestations of a whole roomful of friends and kindred have failed to convince the patient that she had not been lasciviously approached during her anæsthetic sleep. So many cases of this kind are now on record,[1] so many stainless reputations have been assailed as the result of this curious psychical phenomenon, that the surgeon hardly deserves commiseration who out of neglect of so simple a precaution as the insistance upon the presence of a witness or witnesses becomes the victim of a baseless charge of this kind.

The assistant selected as administrator of the anæsthetic should be skilled in the mechanical details of the process and familiar with the line of physiological effects to be produced: too often this important process is entrusted to a callow student or an uninstructed nurse. The assistant should confine his attention strictly to the progress of the anæsthesia and the condition of the patient, not allowing his attention to be distracted by a desire to watch the details of the operation about to be performed.

Final Arrangements.—All instruments and appliances likely to be required during the progress of the operation should be carefully and conveniently arranged before the administration of the anæsthetic begins, but there should be no ostentatious display of instruments. In dental operations the tooth or teeth to be extracted should be examined, and the forceps or other instruments best adapted for the case in hand selected and placed within convenient reach of the operator, but out of sight of the patient. Both operator and assistant should avoid all flippancy of conduct or of speech, and carefully refrain from any act likely to produce disquiet in the patient or disturb his or her mental equipoise. However trifling the ordeal through which the patient is about to pass may appear to the operator, it assumes in the mind of the patient a far greater magnitude, and indeed is never without its dangers: by manners grave but gentle and assured much can be done to quiet apprehension and strengthen confidence.

No administrator of anæsthetics can be regarded as perfectly equipped for his task who has not provided himself with stimulants necessary for use in cases of syncope. Among these must be included a well-constructed electric battery. A tracheotomy-tube and instruments necessary for performing the operation should also be at hand.

Administration of the Anæsthetic.—The patient being fully prepared, the administration of the anæsthetic may begin. Assuming

[1] See article on "Dental Jurisprudence," Vol. III.

that the ordinary cone-and-sponge inhaler is to be used, about half a fluidounce of ether is poured upon the sponge, additional amounts being from time to time added as required; the inhaler is placed over, but not upon, the mouth and nostrils of the patient, who with a few reassuring words is directed to take full and deep inhalations. With timid or nervous persons previous instruction in this is advisable. Silence should at this time be observed in the operating-room, as conversation distracts the attention of the patient and is likely to prolong the period of consciousness. Owing to the irritant effect of the vapor and the suffocative feeling produced, these first inhalations are taken with great reluctance: the patient will frequently attempt to move the face from beneath the inhaler or to push it away with the hands. These efforts should be gently but firmly restrained, and the inhaler be retained in position, care being taken to allow enough space between it and the face to permit the passage of ample volumes of atmospheric air. The fact cannot be too much emphasized that without air there is no safety for the patient, and that the guiding principle of the administration is not the pouring into the air-passages of the largest amount of concentrated ether vapor in the shortest possible space of time, as one might pour the liquid ether through a funnel into a bottle, but a veritable dosage, through the respiratory tract, of vaporous ether in such a degree of solution or attenuation in atmospheric air as shall render it least irritant to, and at the same time most readily absorbable by, those surfaces through which it must pass by osmosis into the circulation. Too concentrated a dosage by the lungs, as by the stomach, may defeat its own end.

When the administration of the anæsthetic is pushed with any degree of boldness and skill, consciousness will very speedily be abolished, this effect coming on very early in the process, and for a time the patient will inhale the vapor more freely and naturally. In those cases in which the contact of ether vapor proves irritative to the bronchial passages a more or less profuse mucous excretion will be excited, which, mixed with the increased salivary outflow, often accumulates in the fauces in quantities sufficient to obstruct respiration. Even when anæsthesia is considerably advanced the patient often automatically relieves himself of these accumulations, and in a manner quite regardless of the safety of those around him. When relief is not obtained by coughing and spitting, the surgeon can sometimes clear the fauces by means of a linen napkin or handkerchief wrapped around the forefinger. When all means fail and the accumulations still persist, as indicated by bronchial and pharyngeal râles and obstructed respiration, the administration of the ether should be discontinued until the patient has recovered consciousness sufficiently to free the air-passages by voluntary effort, when the giving of the ether may again be resumed, a greater degree of tolerance of the vapor being usually manifested by the mucous surfaces.

Vomiting or the effort to vomit often occurs during the administration of ether. Unless the stomach contains food this reflex movement is troublesome rather than dangerous; but as the surgeon can rarely be absolutely certain that the stomach is entirely empty, it is always advis-

able to discontinue the anæsthetic and turn the patient into such a position that ejected substances may fall out of the mouth and not back into the fauces, whence they might possibly be drawn into the larynx. The safe accomplishment of the act of emesis is the assurance of a danger passed, and the administration of the anæsthetic may be continued with increased confidence.

As the patient passes gradually under the influence of the drug, that stage of narcosis (second stage of Brunton) arrives in which, while conscious cerebration has ceased and the sensory and nervous systems have become partially paralyzed, the motor nervous tracts still remain capable of a high degree of excitation, the result generally being that the muscular system is thrown into a state of rigidity or becomes the seat of convulsive movements tetanic in character, and, as already stated, often very violent in degree. Under these circumstances the patient must be restrained with whatever force may be necessary from inflicting violence upon himself or others. Frequently the muscles of respiration will share in the general rigidity, and all respiratory movement cease for what often appears to the anxious operator to be an interminable period, but which really rarely exceeds fifteen or twenty seconds of time. This cessation of respiration is not by any means an alarming symptom, and must not be confounded with that due to paralysis of the respiratory centres, which is one of the accidents of anæsthesia to be hereafter considered: the general muscular rigidity, the full and bounding pulse, the absence of lividity,—all indicate that the cessation of respiratory movement under consideration is less grave in character. Indeed, its duration is self-limited: the ether vapor already diffused in the blood, reinforced by that which during this period of pause passes from the lungs into the circulation, soon produces muscular relaxation—an effect which is hastened by the want of oxygen; which latter want, too, speedily impels to fresh respiratory movements.

As soon as respiration is resumed the operator should be ready with a freshly-charged inhaler to renew the administration of the anæsthetic and bring the patient, with as much expedition as is compatible with safety, to the third or anæsthetic stage of the process, in which there is universal functional depression, attended by complete loss of sensibility; which stage begins as muscular rigidity is succeeded by muscular relaxation, and is completed only when muscular relaxation is absolute.

In bringing the patient to this stage of anæsthesia the careful operator should be studiously watchful of its progressive phases: knowing the normal physiological effects of the drug, he will be able to differentiate them from those which are unusual and dangerous in character. The condition of the pulse should be carefully observed, not so much as an index of the progress of anæsthesia as of the safety of that progress: any irregularity in rhythm or sudden failure in strength should be promptly recognized and met by appropriate measures; as, too, should like aberrations in the respiratory function.

Tests for Full Anæsthesia.—Full muscular relaxation is regarded as the best general test as to the completeness of anæsthesia and the fitness of the patient for the surgical procedure. This test is best applied by lifting the arm of the patient to a moderate height and releasing it: if

upon being released the arm falls perfectly flaccid and powerless, a degree of muscular relaxation is indicated which is compatible only with a narcosis so advanced as to involve in a full degree the general sensory tracts, and general sensation will, as a rule, be found abolished.

A more delicate test, and one preferred by many, is an appeal to the nerves of sensation themselves. The point usually selected for this experiment is the conjunctival surface at the ciliary border. To apply the test, place a finger below the eyebrow and gently raise and slightly evert the eyelid, lightly touching its everted edge with a finger of the other hand. Any winking or spasmodic closure of the eyelids under this palpation is evidence that the anæsthesia is not yet absolute; but if they remain immobile an almost total abolition of sensation is indicated, and the most severe surgical operation can be performed without pain.

Prolongation of the Anæsthetic State.—If the operation is a prolonged one, the administration of the anæsthetic should be continued from time to time throughout its progress, the administrator, as already enjoined, confining his attention strictly to this duty, and not allowing his mind to be diverted from a careful observance of the condition of the patient by a desire to watch the progress of the operation. In operations upon the oral cavity the inhaling apparatus must of necessity be laid aside, at least for a time, and in dentistry a renewal of the anæsthetic is rarely necessary. In oral surgery, however, operations are frequently so prolonged that fresh doses of the anæsthetic become very desirable; but owing to the profuse and often frightful hemorrhage which, in consequence of the vascularity of the parts, attends this class of operations, a renewal of the anæsthetic is attended with no inconsiderable danger, and for its safe accomplishment requires both skill and courage on the part of the operator. The best method of avoiding the danger of suffocation under such circumstances is to place the patient upon one side, or even face downward, thus allowing the tongue to fall forward and the blood and saliva to flow out of the mouth instead of into the pharynx. This expedient, together with the frequent sponging of bleeding surfaces, will enable the operator to reapply the inhaler and bring the patient again fully under the anæsthetic influence.

Treatment of Patient after Anæsthesia.—Upon the completion of the operation, especially if it has been at all severe or prolonged, the patient should be kept under careful surveillance for several hours, or, in any case, until he has fully rallied from shock or depression. The proper temperature of the room in which he is placed has already been alluded to, and its importance must here be emphasized. Many cases of fatality are doubtless attributable to the depressing effects of cold in apartments imperfectly heated: after an operation attended by a great loss of blood the depression produced by this loss, as well as that due to the anæsthetic, will be intensified by external cold, and under these combined influences the vital powers may collapse. When, as often occurs in army practice, it is not possible to secure apartments properly heated, the temperature of the patient may be maintained by means of heated applications made directly to the body: heated bricks, cloths, bottles of hot

water, etc. are among the most useful, and should be freely used until the patient has fully rallied.

The Time Required, and the Amount of Ether Used, in Producing Anæsthesia.—The time required to produce the anæsthetic state by means of ether, as well as the amount of the drug usually necessary, both vary with the age, sex, and susceptibility of the patient, the purity of the drug, the temperature of the room, and the skill of the administrator.

In twenty-six cases reported by Surgeon-major J. H. Porter, assistant professor of military surgery,[1] the following results were obtained:

	Min.	Sec.
Shortest time taken to place the patient under the influence of ether . . .	3	30
Longest time " " " " . . .	24	0
Average time " " " " . . .	8	10
Average time under influence	19	6
Smallest quantity used in any one case	2 oz. 4 dr.	
Largest quantity used any one case	9 "	
Average quantity used	5 " 1 "	

Vomiting occurred in eleven cases during or after the administration of the drug.
Excitement occurred in seven cases to a marked degree during or after administration of the drug.
The ether had a specific gravity of 720.2 at 64° F., and was given on an empty stomach by means of Morgan's inhaler.

As to time and amount, these averages are fairly representative of those usually observed in anæsthesia produced by means of ether when an inhaling apparatus other than the cone and sponge is used. The latter form of inhaler is more wasteful, and by its use anæsthesia, although more safely produced, is not effected so rapidly as by more complicated forms; by its use, too, better average results as to vomiting are obtainable than those given in the report.

Illustrative Experiments.—In concluding the subject of anæsthesia by the inhalation of ether the following graphic description by Anstie[2] of experiments upon the human subject, one being upon himself, is here quoted as conveying to the reader a more vivid conception of the phenomena attending ether narcosis than can be obtained from a more formal statement of the sequence of physiological effects usually to be observed:

"In the following experiments an apparatus was used which was a close imitation of that employed by Snow, and figured in his work on anæsthetics. One or two ounces of ether were placed in the interior of the evaporation-box, which was occupied by a spiral so arranged as to compel the atmospheric air to pass over a large surface of ether on its way to the mouth. The tube and facepiece were those of an ordinary Snow's inhaler; the latter was accurately adapted to the face.

"*Experiment I.*—The apparatus having been charged as above described, a man aged forty, in sound health and of muscular build, commenced inhalation for the purpose of allowing an examination of his eyelids, as he had two days previously got a 'spark' of something from the furnace of a forge into his eye, and the part was so unnaturally sensitive that he could not bear it to be handled.

"No voluntary struggling took place, and the vapor did not appear to

[1] See Erichsen's *Surgery*, pp. 61, 62. [2] *Stimulants and Narcotics*, pp. 256–259.

irritate the air-passages. Respiration, which at the commencement was 16 per minute, retained this rate during the whole of the first minute. The pulse (which at the commencement of inhalation was 74) mounted during that time to 96, and was very forcible in its beat. Sixty-five seconds from the first inspiration of ether the patient sat up and looked at me with a roguish leer for a moment or two. He then sank back, and began to babble incoherent nonsense with great fluency, and at first with perfect articulation: by the end of the second minute the pulse had risen to 104, respirations 18; eye somewhat congested, face of the natural tint, pupil apparently unaffected in size and quite sensitive to changes of light. There was now very perceptible diminution in the sensibility of the skin of the hands; there was also commencing rigidity of the muscles of the arms and forearms, and more decided stiffness of the legs. At the end of the third minute articulation had become confused; there was a copious flow of frothy saliva, which the patient made no effort to get rid of; consciousness was apparently lost; muscular rigidity was general and very strong, particularly in the muscles of the neck; face flushed and sweating; eyes very much congested, pupil contracted and insensitive. Pulse 98, respirations 28. At this moment an attempt was made to explore the injured eye, but the lids closed with spasmodic firmness at the first touch on the conjunctiva of their edges. Inhalation was continued for two minutes longer: at the end of this time muscular rigidity had disappeared, the patient was profoundly unconscious, the pupils dilated, and the conjunctiva perfectly insensitive; pulse 96, respirations 21; snoring. The eye was now explored, and the foreign body removed in less than a minute. The patient had completely regained consciousness at the end of seven minutes from the withdrawal of the ether inhaler; pulse 72, respirations 15. At this time, however, and for several minutes longer, there was still some feeling of numbness in the feet and in the calves of the legs, slight dizziness, and a slight deficiency in the co-ordination of the movements of the lower limbs in walking. On examining the inhaler three ounces of ether were found to have been used.

"*Experiment II.*—An ounce of ether having been placed in the inhaler, the facepiece was made fast to my own face by strips of adhesive plaster. My watch was placed before me in such a position that I could easily see the movements of the second-hand. With pencil in hand I made a simple mark upon paper for each fifteen seconds so long as consciousness lasted: I had no assistant in this experiment.

"With the exception of the odor of the ether being very unpleasant, my sensations were highly agreeable, and no irritation of the air-passages was occasioned, although the outer valve of the facepiece was left more than three quarters closed from the first. The first symptoms were those of simple exhilaration and warmth extending all over the body: the pulse was somewhat increased in frequency, and the heart's action became strong and perceptible to myself. For more than thirty seconds I experienced no other feelings than these. A sense of numbness and indistinct tingling then began to affect the feet, and spread upward with considerable rapidity. Almost simultaneously perspiration broke out on the forehead, and I began to be dizzy, with a feeling as if the room was spinning round. I felt a strong inclination to laugh, and I believe I did so. It was now impossible for me to see the movements of the second-hand of the watch or even the large figures; my limbs felt like lead, and almost the last thing of which I was conscious was that my pencil fell out of my hand, and that I could neither see it on the floor nor move my foot to feel for it.

"On recovering consciousness I could not at first move any of my limbs, and the room still seemed to spin round; the facepiece was still firmly attached. It was some little time before I could distinguish the figures on my watch: when I had accomplished this it appeared that thirty-five minutes had elapsed since the commencement of inhalation. I was comfortably cool, but my face was damp with copious perspiration. There was still a sensation of numbness and tingling in all my limbs, and on attempting to walk I could not manage my legs. In less than five minutes more I had perfectly recovered. It appeared that I had only made two marks upon the paper: this proved that I had become unequal to the requisite movements or oblivious of the matter before the forty-fifth second from the commencement of inhalation. All the ether in the apparatus had been used."

Dangers of Ether Narcosis.

Attention has thus far been directed chiefly to those phenomena of ether narcosis which are usual in character, and which do not to an alarming degree impair the vital powers of the subject or put life in jeopardy; but as the whole process of anæsthesia, whatever agent be used, is simply an assault upon the functional integrity of the great centres of vitality, the toxic influence being subject only to such limitations as are inherent in the nature of the drug employed or as are dependent upon the manner of its administration, it follows that there is always a possibility that the line of safety may at any moment be passed and dangerous complications manifest themselves.

One of the marked physiological effects of sulphuric ether is that in the progressive paralysis of the vital functions which it produces the respiratory centres usually become depressed far more rapidly and deeply than the circulatory, the heart frequently continuing to beat for several seconds, or even minutes, after respiration has ceased. The dangers of ether narcosis are therefore to be looked for chiefly in this direction, and while both pulse and breathing should be closely watched, any failure in the former will generally be found to have been preceded by a marked depression in, or total cessation of, the latter function. Broadly stated, ether kills by apnœa, and not by syncope. This rule, however, is not by any means invariable, as heart failure is occasionally the first indication of danger, the respiratory movements being at the time comparatively unaffected.

Insufficient Anæsthesia.—Ether under certain conditions, as has just been intimated, is quite capable of seriously weakening the force of the cardiac impulses, and even a fatal arrest of cardiac movement may result from the combined influence of the operation and the anæsthetic. This result may, of course, follow when too much of the drug has been given, but it is also a possible consequence of giving too little. Very soon after the introduction of modern anæsthesia Sir James Y. Simpson announced as a fundamental condition of safety in ether narcosis that, "whatever means or mode of etherization is adopted, the most important of the conditions required for procuring a satisfactory and successful result from its employment in surgery consists in obstinately determining to avoid the commencement of the operation itself, and never venturing to apply the knife, until the patient is under

the *full* influence of the ether vapor, and *thoroughly* and *indubitably* soporized by it."[1]

The necessity for the observance of this rule arises from the fact that in incomplete anæsthesia consciousness may be abolished while the sensory system still remains capable of receiving and transmitting impressions, so that through this system pain may be felt of which the intellectual functions can take no cognizance. The shock from this unconscious suffering may be transmitted to the cardiac and vaso-motor ganglia, already in a state of partial paralysis from ether narcosis, and upon them produce an impression so profound as to result in complete arrest of movement.

This result is possible not alone from the major operations of surgery, but has frequently resulted from operations quite trivial in character and affecting only dermal structures or their appendages. Anstie was the first to point out that the relatively great fatality in such cases was due to the fact that "certain portions of the skin and subcutaneous tissues retain their sensibility with extraordinary tenacity: these are the matrix of the great toe-nail, the margin of the anus, and the whole of the skin of the organs of generation. It is impossible," he says, "to obliterate their sensibility without pushing chloroformization to a degree which greatly surpasses that required for ordinary purposes. This observation is confirmed by my experience with animals, and its importance cannot be too highly estimated; for it explains the frequency with which death has happened in the course of anæsthesia induced for the performance of operations for phimosis, evulsion of the toe-nail, hemorrhoids, etc. All kinds of fanciful reasons have been given for this fatality of chloroform in such trifling operations, but there is no doubt in my mind that this is the true one."[2]

The peculiar toxic power of chloroform is such that fatality as the result of its insufficient use in such cases of retained sensibility is far more likely to follow than from the employment of ether; still, the danger exists with both, and must not be lost sight of. Many of the deaths which have followed the use of anæsthetics in dental surgery have no doubt been due to the insufficiency of the dose; and there can be no question that those branches of the fifth nerve distributed to the teeth, especially when their sensory activity is intensified by pulp-irritation or by inflammation of the root-investments, are among the nervous tracts which retain sensibility late in the anæsthetic process; which fact, coupled with the close connection between the nucleus of the fifth and that of the inhibitory nerve of the heart, often sufficiently accounts, even when other reasons are lacking, for the mortality which has so frequently attended tooth-extraction. As early as 1867, Dr. Reeve[3] called attention to the special danger of insufficient anæsthesia in dentistry—a position which is fully sustained by Bartholow, who says:[4]

"*Incomplete anæsthesia is a condition of danger.* Numerous accidents have occurred from the use of anæsthetics for trivial operations—notably,

[1] *Anæsthesia*, pp. 158, 159. [2] *Stimulants and Narcotics*, pp. 305, 306.
[3] *American Journal of the Medical Sciences*.
[4] *Materia Medica and Therapeutics*, pp. 362, 363.

for extraction of teeth—in which but a partial degree of insensibility is induced. In such cases the heart, enfeebled by chloroform narcosis, is suddenly paralyzed by the reflex action proceeding from the peripheral injury. The district of tissue supplied by the fifth nerve is an especially dangerous region, owing doubtless to the intimate connection of the nucleus of the fifth with the nucleus of the pneumogastric. By far the largest number of fatal cases have resulted from a neglect of this rule: it is never safe to proceed in a surgical operation with anæsthetics unless complete insensibility has been produced."

Dr. Lauder Brunton in Coleman's *Dental Surgery and Pathology*[1] gives the following explanation of the nervous mechanism through which irritation of the fifth nerve during tooth-extraction operates upon the vascular system:

"The blood when it reaches the veins is useless for the nutrition of the tissues, as we see in a corpse when the whole of the blood in the body is contained in the veins, the arteries being empty: only so long as it is in the arteries can it maintain the vitality of the tissues. The blood is kept in the arteries—1, by fresh supplies being pumped out of the venous system into the arterial by the heart; 2, by the contraction of the arterioles, which prevents it from running back too quickly into the veins.

"When a tooth is drawn without chloroform the irritation is carried by the fifth nerve to the nerve-centres: it irritates the vagus roots and also the vaso-motor centre. The irritation of the vagus may depress or arrest the heart's action, so that no blood is sent into the arterial system for several seconds; but this is counterbalanced by the irritation of the vaso-motor centre, which causes contraction of the arterioles, and thus correspondingly diminishes the outflow. In a person thoroughly under chloroform *both* nerve-centres have their reflex sensibility abolished, and so the irritation has no effect upon either; but with partial anæsthesia the vaso-motor centre may be rendered insensible before the vagus centre, and consequently when the irritation is applied to the fifth nerve the vagus centre only is excited, the heart is depressed or stopped, and the inflow of blood into the arterial system is diminished or arrested, while there is no contraction of the arterioles, and therefore no corresponding diminution of the outflow. The arterial system therefore becomes more or less empty—*i. e.* it approaches more or less the condition of death, and fatal syncope may result."

In the following diagram (Fig. 4), Dr. Brunton illustrates the course of the nervous impulses, producing arrest of the heart's action, following the extraction of a tooth from a but partially-anæsthetized person.

Signs of Danger in Ether Narcosis.

Failure of Pulse.—The chief indication of impending heart paralysis will be found in failure of the pulse, it becoming weak in quality and irregular in rhythm, these symptoms being possibly followed by its total cessation. In such cases the face and lips will become bloodless and hemorrhages from wounded surfaces will cease.

[1] See *Manual of Dental Surgery and Pathology*, by Alfred Coleman, L. R. C. P., F. R. C. S., etc., thoroughly revised and adapted to the use of American students and practitioners, by Thomas C. Stellwagen, M. A., M. D., D. D. S., Professor of Physiology at the Philadelphia Dental College, pp. 337, 338.

Interference with Respiration.—So far as interference with the respiratory function is concerned—the chief source of danger when ether is administered—the symptom which most urgently demands attention is a respiration either hurried, labored, intermittent, gasping, or stertorous. As has already been stated, the mere temporary suspension of respiration, which so often occurs as the result of the fixation of the respiratory muscles during the tetanic stage of etherization, need not excite alarm

FIG. 4.

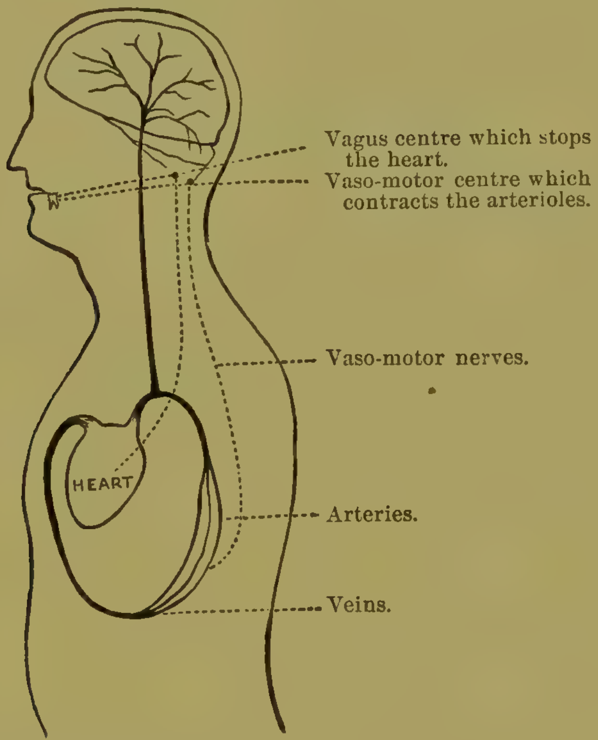


Diagram illustrating Lauder Brunton's views of the cause of arrest of the heart's action under chloroform administration.

unless attended by other abnormalities in the appearance or condition of the patient, such as great lividity of the face, irregularity or failure of the pulse, etc.; and, indeed, this statement is equally applicable to other of the aberrations in the rhythm or quality of the respiratory movement to which attention has just been called. Up to the time of complete muscular relaxation the respiration is often exceedingly irregular, at one moment hurried and at another shallow and labored; sometimes it is intermittent, the semi-conscious patient being apparently in a state of lethargy, and, for the time, quite oblivious to the necessity for breathing until aroused by the voice or touch of the operator. After complete relaxation of the voluntary muscular system has taken place, however, the respiratory movements, while slow, are usually deep and rhythmical: at this time, therefore, any abnormalities in character are to be carefully regarded. In brief, it may be stated that aberrations in the respiration are grave when they come on late in the anæsthetic process, or when in any stage they are prolonged and are attended either by excessive lividity or great pallor of the face, and by irregularity or failure of the circulation.

Gasping Respiration.—Of special significance is what has been described as gasping respiration, in which the mouth is opened widely and the air in full volume is drawn convulsively into the trachea, producing, as it passes over the vocal cords, those highly-pitched, resonant inspiratory vibrations characteristic of a gasp. This form of respiration is generally shallow or superficial in character, the air-current appearing to dilate the minute air-passages to but a limited extent, and is always indicative of a grave interference, through the respiratory centres, with the mechanism of breathing.

Stertorous or snoring respiration is a symptom demanding the closest watchfulness, and is grave just in proportion as respiration is interfered with and the muscular relaxation upon which it depends is partial or absolute. The tongue becomes partially paralyzed quite early in the anæsthetic state, as is indicated by the inability of the patient to clearly articulate words and sentences, and even in this state of incomplete paralysis it may fall back against the relaxed velum, thus shutting off the passage of air from the mouth into the larynx, except as the velum is lifted by the narrowed and intensified air-current and thrown into those rude vibrations which produce the sound of snoring. The velum, resting as it does against the dorsum of the tongue, acts as an imperfect valve to the returning air-current, and, notwithstanding that the mouth is widely open, often causes it to escape chiefly through the nasal passages. In the deeper forms of stertor this valvular function is less perfectly performed, and expiration as well as inspiration takes place through the mouth. It is, of course, evident that under the circumstances described respiration is to a greater or less extent obstructed, and thus one of the conditions vitally essential to safety in anæsthesia is impaired.

Those more complete muscular relaxations in which simple snoring deepens into a profounder stertor are of even a graver significance: the buccinators may share in the general loss of muscular power and flap to and fro in the incoming and outgoing air-currents, while the tongue may become so completely paralyzed as to fall back upon the glottis, thus not only producing an almost complete laryngeal stenosis, but indicating a degree of muscular paralysis compatible only with a profound and dangerous narcosis—a narcosis which may at any moment culminate in a complete suspension of the respiratory functions.

Laryngeal Stertor.—Lister has called attention to the fact that a snoring respiration may be purely laryngeal in character, due to "the vibration of the portions of mucous membrane surmounting the apices of the arytenoid cartilages—*i. e.* the posterior parts of the aryteno-epiglottidean folds (thick and pulpy in the dead body, but much more so when their vessels are full of blood), which are carried forward to touch the base of the epiglottis during stertorous breathing, and are placed in still closer apposition with it when the obstruction becomes complete."[1] To laryngeal stertor Lister attaches much more significance than to that dependent upon palatine vibrations.

Delusive Chest Movements.—Cases sometimes occur in which the walls of the chest rise and fall even after air has ceased to enter the lungs. This failure is not always dependent upon obstruction of the glottis, for

[1] Holmes's *System of Surgery*, vol. iii. p. 531.

in experiments upon animals it has been observed even when the anæsthetic has been administered by a canula introduced through an opening made in the trachea. Murray[1] attributes the phenomenon to a failure in the co-ordination of the inspiratory and expiratory muscles, or to an antagonism between the "action of the diaphragm" . . . . "and the action of the muscles of expiration," the result being a "respiratory stammer" precisely analogous to the inco-ordinate speech of inebriety. Whatever may be the true rationale of the phenomenon, the clinical fact is of the utmost practical importance, for unless instructed in regard to the possibility of this danger the operator, deceived by the continuance of the chest movements, would fail to notice that the lungs are no longer receiving air until warned of the fact by signs of impending asphyxia or collapse.

Irregularities of Pulse.—All the more serious interferences with respiration are always attended by aberrations in the force and frequency of the pulse. Even with ether it sometimes, although rarely, happens that as the result of organic weakness or susceptibility the circulation is primarily affected, the pulse becoming weak, irregular, intermittent, fluttering or running, or even ceasing altogether, these evidences of cardiac paralysis being, of course, followed by abnormalities in respiration. In syncope the hemorrhage from wounded surfaces ceases. In apnœa the blood assumes the venous hue due to imperfect aëration.

The methods for antagonizing these dangerous conditions now demand consideration.

Treatment of Dangerous Symptoms.

Whenever in the progress of ether narcosis dangerous symptoms are manifested the primary indication is the withdrawal of the anæsthetic, the simple readmission of full volumes of fresh air to the respiratory tract often sufficing to effect the recovery of the patient. As the air of the room in which the ether has been given is generally pretty thoroughly impregnated with the vapor of the drug, it is well to open doors or windows, as may be most convenient, for the purpose of admitting a purer air from the outside. During cold weather, however, care must be taken that the temperature of the room, and consequently of the patient, is not too much lowered by this freedom of ventilation, cold, as has already been explained, being quite capable of effecting a fatal depression of the vital powers.

This consideration must be borne in mind when the dashing of cold water into the face or upon the chest is resorted to. The object is, of course, to excite the reflexes to activity by a sudden stimulation of the superficial sentient nerves; but as these undergo a paralysis more or less complete quite early in the anæsthetic state, the plan is hardly likely to prove so effective as it would in an ordinary case of fainting or syncope; still, there are many cases on record in which apparent benefit has been derived from this practice; but the fact must not be lost sight of that a too prolonged exposure to cold water or the too frequent application of the douche is certain to do harm.

[1] *British Med. Journ.*, Sept. 19, 1885.

A far more effective method of exciting the reflex activity of the respiratory system is stimulation of the pharyngeal branches of the pneumogastric. This may be effected by passing the finger into and touching the walls of the fauces, where, and in the mucous membrane of the larynx, sensation is retained to a very late period in the anæsthetic process.

No small part of the benefit derived from drawing forward the tongue when it has fallen back into the fauces is unquestionably due to the reflex stimulation of the respiratory centres which its forcible extension produces.

It has thus far been assumed that the directions already given as to the preparation of the patient for, and position during, the inhalation of the anæsthetic have been fully followed. If, however, the clothing has not been so fully loosened as to give the utmost freedom of movement to the walls of the chest and abdomen, this should at once be done; and if the patient has not been kept in the recumbent position, he should without a moment's delay be so placed, thus favoring the flow of blood to the brain by the force of gravity, and to that extent diminishing the force of the cardiac contraction required to effect its impulsion thither. Indeed, where the evidences of cardiac failure are very marked, and great pallor of the face and lips indicates a state of cerebral anæmia, it is desirable that the head should not only be as low as, but lower than, the rest of the body; in extreme cases even the inversion of the body has been recommended and successfully practised by Nélaton and others. This, however, is a procedure more likely to be demanded when chloroform has been employed as an anæsthetic, and it will be further commented upon in connection with the use of that drug.

Howard's Method.—Allusion has already been made to the pulling forward of the tongue when it has fallen back into the pharynx; and this act of simple traction upon the organ has generally been regarded as amply sufficient to relieve the mechanical obstruction to respiration due to its abnormal position. Dr. Benjamin Howard was the first to call attention to the fact that in the supine position ordinarily assumed in anæsthesia the forcible drawing forward of the tongue in cases of respiratory obstruction has very little if any effect in lifting the epiglottis and thus permitting free access of air to the larynx. Dr. Howard recommends that the patient be placed upon his back, with a bundle of clothing or some other firm substance under the shoulders for the purpose of elevating the thorax, the head and neck to be placed in extreme extension backward; thus the patient will be lying with the under part of his chin rather than his face presenting to the ceiling of the room; in other words, the head of the patient is in very much the same position as if his whole body was inverted. It is evident that when a man is thus placed, head downward, a paralyzed tongue by simple gravitation will fall against the roof of the mouth, whereas in the supine position, face upward, gravitation naturally carries it against the posterior wall of the pharynx.

Dr. Howard claims that the extreme extension backward of the head and neck which he recommends effects such extensions and adjustments

of the muscular apparatus of the throat, larynx, and fauces as secure, if the nares be permeable, an unobstructed "post-oral air-way," the mechanism, as described by Dr. Howard, being as follows:[1]

"The position consists in elevation of the thorax and complete extension backward of the head and neck. By this means the line of gravitation of the tongue is shifted from the back of the pharynx to the hard palate at or about its junction with the soft palate. The entire posterior wall of the pharynx is shifted backward, its anterior wall is shifted forward; thus its antero-posterior diameter, as much as is possible, is throughout increased, while by the shifting upward and backward of the nares their entrance is brought more directly over, and in a line with, the course of the pharynx.

"The larynx being pulled downward and forward by the sterno-hyoidei muscles, and fixed there, the extension motion upward and backward of the lower jaw puts upon the stretch the genio-hyoidei, mylo-hyoidei, and anterior bellies of the digastric muscles, causing the hyoid bone and—by means of the hyo-epiglottic ligament—the epiglottis to share together the motion of the jaw. Thus the epiglottis is instantly made vertical, the thyroid insertion of the palato-pharyngei muscles being brought downward and forward by the sterno-thyroidei and fixed; the palato-pharyngei muscles are put upon the stretch in their whole length by the movement upward and backward of the head in extension, and thus the posterior pillars of the fauces, the arches of the palate, and velum palati, into which latter membrane they are inserted, are all pulled downward and forward; they are thus made tense, and kept so. The velum thus stretched some distance in front of the back of the pharynx, a post-oral air-way is secured, from which the tongue is doubly excluded."

These anatomical points have been demonstrated by Dr. Howard upon the cadaver, and the advantages of the position he recommends are now generally conceded.

Drawing Forward the Tongue.—Dr. Howard regards the drawing forward of the tongue, in connection with his position of extreme extension backward of the head and neck, as "highly advantageous, though not necessary," but recommends that when it is attempted the jaw should be lowered as little as possible.

In attempting traction upon the tongue it may sometimes be successfully grasped by the fingers protected from contact with its slippery surface by a dry towel or napkin, or a pair of large bullet forceps similarly protected may be used. A tenaculum has been recommended, but this is too slight an instrument to be used in making the necessary traction. Kappeler[2] recommends in extreme cases piercing the tongue through its entire thickness with a thread sufficiently strong to bear the strain necessary to effectively draw the organ out of its malposition. This author has demonstrated on the cadaver (as did Howard) that drawing forward the tongue "has only the effect of opening the pharynx, while the epiglottis remains unmoved or is hardly observably

[1] "An Anatomical Remedy against Respiratory Obstruction from the Tongue, Epiglottis, and Velum Palati in Threatened Apnœa from Anæsthesia and Other Causes," by Benj. Howard, A. M., M. D., M. R. C. S., Eng: *Proceedings Med. and Chirurg. Soc.*, May 14, 1878, pp. 331–333.

[2] *Anæsthetica*, pp. 126, 127.

lifted, unless the traction is so strong that both the under jaw and the hyoid bone are drawn forward with the tongue."

Drawing Forward the Under Jaw.—In this connection Kappeler recommends a method of drawing forward the under jaw, to be accomplished by placing the thumbs upon the cheeks of the patient close to the nose, the bent fingers behind the angle of the jaw upon either side, and making the traction required. He has shown upon the cadaver that "through the drawing forward of the lower jaw the tongue and hyoid bone are also moved forward; the epiglottis, following through tension upon the hyo-epiglottic ligament, will be placed upright, so that when one can" (in a prepared cadaver) "look from above into the throat, the rima glottidis will be seen coming fully into view."

When any or all of these efforts to relieve mechanical obstruction or to excite the respiratory reflexes fail to accomplish their purpose, recourse must be had to some one of the methods of artificial respiration.

Artificial Respiration.

Insufflation.—One of the oldest methods of inducing artificially the inflow and outflow of a current of air through the respiratory tract is the inflation of the lungs of the subject directly from those of the operator by the mouth-to-mouth process. This often succeeds with newly-born infants, but certain mechanical obstacles render it difficult of accomplishment with adults, one of the chief of these being that of securing a coadaptation of the labial orifices sufficiently close to establish a continuous and unbroken air-passage. This difficulty can be overcome by interposing a tube between the mouths of the operator and the subject respectively, the lips of the latter being closed around the tube by the fingers either of the operator or of an assistant. Or the delivery end of the tube may be placed in one nostril of the patient, the other nostril and the mouth being firmly compressed to prevent the escape of air. For this reason compression of both nostrils must be practised where the mouth is used as the avenue for inflation; and in order to prevent the air from passing into the œsophagus and stomach, instead of the trachea and lungs, the larynx should be firmly pressed backward for the purpose of compressing the œsophagus between the laryngeal walls and the spinal column. The objection urged against these methods of direct insufflation, that air coming directly from the lungs of one person contains too little oxygen and too much carbon dioxide to satisfy the respiratory needs of another, is only measurably true: respired air is contaminated, but is by no means absolutely useless for breathing purposes, and, in point of fact, must be breathed and rebreathed several times before it becomes entirely unfitted to sustain life. The operator may very much improve the quality of the air which he blows into the lungs of the patient by filling and emptying his own lungs several times in rapid succession previous to each act of insufflation. The whole process, however, is, with adult patients at least, laborious and disagreeable in its details and difficult of successful accomplishment: its great merit is that the mouth-to-mouth process can be resorted to without the delay

incident to the use of artificial inflating apparatus, while by the use of the latter a purer air is obtained and fatigue upon the part of the operator is avoided.

The ordinary fire-bellows is the most familiar and efficient, as well as the simplest in its construction, of these forms of apparatus. Of more modern construction are insufflation-tubes attached to bulbs of elastic rubber, the bulbs being furnished with valves so arranged as to admit air at their free ends and under suitable compression allow its egress only at the other or tube ends. By placing the nozzle of such a tube or of the ordinary bellows in one nostril or in the mouth of the patient a speedy inflation of the lungs may be effected, it being of course understood that the same precautions are to be observed as in direct insufflation.

Whichever of these methods may be adopted, care must be observed not to distend the lungs of the patient too forcibly, owing to the possibility that rupture of the air-vesicles may thereby be caused. The object of the operator should be simply to gently distend the lungs to about the same degree, and with about the same frequency, as in normal respiration. The elasticity of the lung-tissue and of the thoracic walls is usually sufficient to produce a satisfactory expiratory result, although this may be assisted by gentle compression of the walls of the chest. When the thorax becomes apparently expanded, and so remains without subsidence, it may be taken as an indication that through some failure in manipulation the air-current has followed the line of least resistance, and passed into the œsophagus, instead of the larynx; indeed, any other result will be impossible if access to the latter is closed by pressure of the tongue upon the epiglottis. In such cases placing the patient in Howard's position would seem to be the only means of rendering possible any method of insufflation through the oral or nasal cavity: certainly, the expedient suggested by some writers of passing the insufflation-tube through the rima glottidis into the larynx will be found difficult, if not impossible, of accomplishment, except perhaps by expert laryngologists.

Tracheotomy.—A far more practicable and effective procedure, and one which in extreme cases should always be adopted, is the performance of tracheotomy. This is especially effective in spasm of the glottis or in pharyngeal or laryngeal obstruction proceeding from whatever cause, and even in cases of true respiratory paralysis it affords, other methods failing, the most effective means of emptying the lungs of ether vapor and of re-establishing by insufflation the normal respiratory current. It is quite certain that lives have been saved by a prompt recourse to this method, and that many more might have been had it been resorted to.[1]

Report on Suspended Animation.

In concluding the subject of insufflation the views regarding "the position of the tongue and its influence in impeding the entrance of air," expressed by the committee appointed by the Royal and Medico-

[1] For a description of the operation of tracheotomy the reader is referred to the article on "Oral Surgery," Vol. III.

Chirurgical Society to investigate the subject of suspended animation, may here be quoted. The views as given are the result of careful experimentation upon the cadaver, and, as will be seen, fully sustain—or, rather, anticipate—Howard's position upon the point, his method having been published many years after the report of the committee was given to the world. The committee say:[1]

"It was found that in the dead body this organ" (the tongue) "is apt to offer great obstruction to inspiration by falling back into the pharynx and closing the laryngeal aperture. No air could be forced through the mouth in a body lying on the back so long as the tongue remained undisturbed, but when it was drawn forward and held out of the mouth by a ligature or by the pressure of the teeth upon it, air could be injected by the œsophagus and larynx, so as to distend both the abdominal and thoracic cavities.

"*When the head of the subject was allowed to hang back over the edge of the table, air seemed to pass into the chest more readily than when the back of the head rested against the table.*

"It was found that the whole quantity of air introduced by inflation could be compelled to enter the respiratory cavity by pressing back the larynx against the spinal column. By this expedient the passage of air down the œsophagus was at once interrupted, while its transit down the trachea continued as before; so that it affords a ready means of preventing the passage of air into the stomach during artificial respiration."

Manipulative and Postural Methods of Artificial Respiration.

These methods, although differing in detail, have for their purpose the placing of the patient in positions best fitted to favor normal respiratory movements and of reproducing artificially those movements by alternate manual compression and relaxation of the walls of the thorax.

Dr. Marshall Hall's Method.—This has been called the "ready method" or "the method of prone and postural respiration." It consists in placing the patient in the prone position, making gentle pressure upon the back, turning the patient upon his side and a little beyond (or nearly supine), replacing him briskly upon his face, making gentle pressure upon the back, and turning upon the side as before; these movements being repeated about fifteen times in the minute until natural respiration is resumed.

As the patient in the execution of these movements is placed face downward, the weight of his body, aided by pressure upon the back, compresses the walls of the thorax, diminishes its calibre, and forces out a portion of the residual air contained in the lungs. As the patient is turned upon his side this mechanism is reversed; the chest-walls, being relieved of pressure, immediately, by virtue of their elasticity, expand; a corresponding increase in chest capacity occurs, the inflow of air into the lungs being favored by the partial vacuum thus created.

Dr. Silvester's Method.—The essential features of this method, as at present practised, are as follows: Place the patient supine upon a flat

[1] Report read July 1, 1862: see *Med.-Chirurgical Transactions*, vol. xlv.

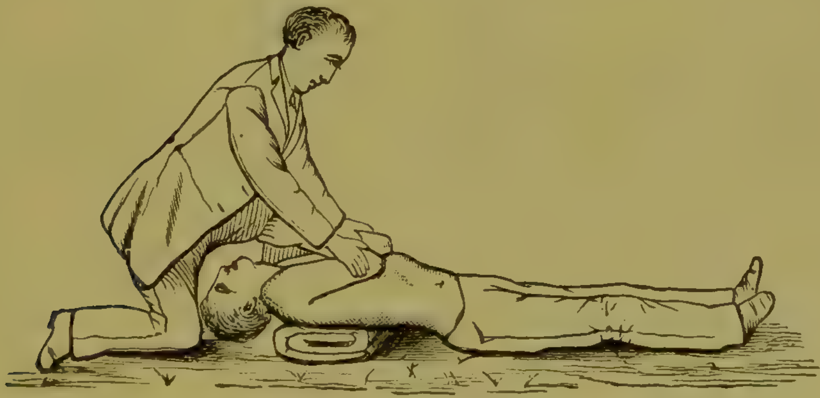
surface, the chest being elevated by a cushion placed beneath the shoulders, the head hanging backward in Howard's position. Standing behind the head of the patient, grasp his flexed arms near the elbow and draw the extended arms upward and forward upon either side of the patient's head (Fig. 5), for the purpose of putting upon tension the

Fig. 5.

Inspiration (Silvester's method).

pectoral muscles, and thereby elevating the ribs and increasing the chest capacity: to effectually accomplish this pull strongly upon the arms for the space of about two seconds. Then flex the forearms upon the arms and press them firmly against the sides of the chest to expel the air (Fig. 6). Repeat these movements about fifteen times in the minute.

Fig. 6.



Expiration (Silvester's method).

Dr. Howard's Direct Method of Artificial Respiration.—This is the most recently introduced, and perhaps, in its essential features, the most approved, of all the methods now in use. As published in the *London Lancet*,[1] it was prefaced by directions for securing the ejection and drainage of fluids from the stomach and lungs of drowned persons; which directions, although not strictly germane to the subject of anæsthesia, may, as a matter of general interest, be here given; they are as follows:

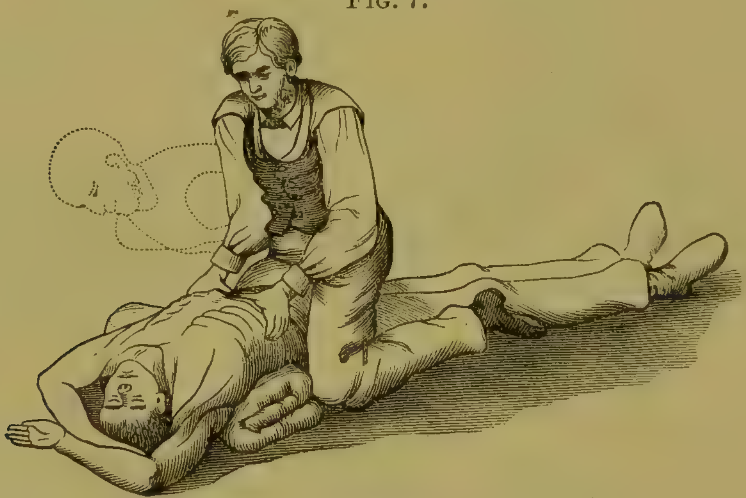
[1] August, 1878, pp. 362–368.

"*Position of Patient.*—Face downward, a hard roll of clothing beneath the epigastrium, making that the highest point, the mouth the lowest. Forehead resting upon forearm or wrist, keeping mouth from the ground.

"*Position and Action of Operator.*—Place the left hand well spread upon base of thorax to left of spine, the right hand upon the spine a little below the left and over lower part of stomach. Throw upon them with a forward motion all the weight and force the age and sex of patient will justify, ending this pressure of two or three seconds with a sharp push, which helps to jerk you back to the upright position. Repeat this two or three times according to period of submersion and other indications.

"*To Perform Artificial Respiration.—Position of Patient* (Fig. 7).—Face

FIG. 7.



Artificial Respiration (Howard's method).

upward, the hard roll of clothing beneath thorax, with shoulders slightly declining over it. Head and neck bent back to the utmost. Hands on top of head. (One twist of handkerchief around the crossed wrists will keep them there.) Rip or strip clothing from waist and neck.

"*Position of Operator.*—Kneel astride patient's hips; place your hands upon his chest, so that the ball of each thumb and little finger rests upon the inner margin of the free border of the costal cartilages, the tip of each thumb near or upon the xiphoid cartilage, the fingers fitting into the corresponding intercostal spaces. Fix your elbows firmly, making them one with your sides and hips: then—

"*Action of Operator.*—Pressing upward and inward toward the diaphragm, use your knees as a pivot and throw your weight slowly forward two or three seconds until your face almost touches that of the patient, ending with a sharp push, which helps to jerk you back to your erect kneeling position. Rest three seconds; then repeat this bellows-blowing movement as before, continuing it at the rate of seven to ten times a minute, taking the utmost care on the occurrence of a natural gasp gently to aid and deepen it into a longer breath until respiration becomes natural. When practicable, have the tongue held firmly out of one corner of the mouth with thumb and finger armed with dry cotton rag."

Howard's views with regard to the influence upon the position of the tongue which is exerted by extreme backward extension of the head and neck have already been given in connection with the subject of insufflation. His opinion as to the influence upon thoracic expansion produced by the position directed for the patient in his method is given as follows:

"1st. By straightening the dorsal curvature of the spinal column. The weight of the trunk resting at this point with its greatest thoracic curvature upon the hard roll of clothing, the curve is diminished, the spinal column is proportionately straightened and lengthened, many of the ribs are moved upward, the interspace between them is increased, the sternum is carried forward, and the general thoracic circumference is thus enlarged.

"2d. By extension of the head and neck. This brings into play the scaleni, sterno-cleido-mastoidei, and all the muscles from the head and neck attached to the upper part of the thorax.

"3d. By extension of the arms. This being directly upward and backward, instead of upward and forward, as in Silvester's position, not only are the same muscles his position uses made more tense, but other muscles, the latissimus dorsi, are also brought into play, and thus the superior costæ, the inferior costæ, and as nearly as possible all the parts of the entire thorax, are submitted to the traction of the muscles presiding respectively over the expansion of those parts."

The Medico-Chirurgical committee on suspended animation, already quoted, carefully tested upon the cadaver the methods of Marshall Hall and Silvester. The following are the results:

"*The Marshall Hall Method.*—As regards that part of the method which consists in turning the body 'very gently on the side and a little beyond, and then briskly on the face,' it was found that the volume of air exchanged was variable in the same subject, but always inconsiderable. It usually happened that a quantity of air varying from one to eight cubic inches—never more, generally much less than eight—was inspired when the body was turned from the supine position to one side. When the body was placed on the abdomen, with the head resting on the forearm, a somewhat larger quantity was expelled, never exceeding ten cubic inches. On restoring the body to the lateral posture the amount of air inspired was usually less than that which had been expelled by pronation. . . . .

"The volume of air expelled when the body was placed on the face was much increased if pressure were at the same time made on the spine. . . . . As regards the whole amount of air introduced, it varied much according as the subject was favorable or the contrary, sometimes not exceeding a few cubic inches, but never exceeding fifteen cubic inches.

"*Dr. Silvester's Method.*—As regards the method above described as that of Dr. Silvester, it was found that on extending the arms upward a volume of air was inspired into the chest which varied, in different subjects, from nine to forty-four cubic inches. . . . . On restoring the arms to the side the quantity expelled was generally nearly equal to that previously inspired, occasionally less.

"Dr. Silvester recommends that on bringing down the patient's arms they should be gently and firmly pressed against the sides of the chest, so as to diminish the cavity of the thorax. It was found that this pressure could be exercised with greater facility and equal effect by placing the hands" (of the operator) "on the lower third of the sternum, as already above described" (making pressure there). "By alternating the movements of the arms with pressure of this kind a regular exchange of air was produced, the quantity of which in several instances exceeded thirty cubic inches, and in one instance amounted to fifty cubic inches.

"As has already been pointed out by Dr. Silvester, the condition of the thorax after cessation of breathing being that of expiration, it is desirable

that the first step in the restoration of breathing should be a movement of expansion; in this respect the method he has proposed enjoys a marked superiority over that of Dr. Marshall Hall, which has for its object to force air from a chest which has already discharged its natural quantity. It also appears to be an important advantage in this method that in each movement of expansion both sides of the chest are left free from compression, and therefore free to move, while the postural method of Dr. Marshall Hall leaves only one side free to expand."

This indorsement of the Silvester method, as modified, was, as previously stated, made before Dr. Howard's process had been given to the public. Had the committee then had opportunity to pass upon it, they could hardly have failed to have anticipated the verdict of later observers, that this, while embracing all the essential excellences of the method of Dr. Silvester, is in point of convenience and efficiency a decided improvement upon it, and is beyond question the best of all known modes of producing artificial respiration in cases of suspended animation.

Faradization.—One of the advantages of Howard's "direct method" is that it does not preclude the simultaneous employment of additional agencies for restoring the respiratory function. One of the best of these is excitation of the movement of the diaphragm through faradization of the phrenic nerves. This form of electrical stimulation may be applied by placing the positive and negative electrodes respectively over the course of the right and left phrenic nerve in the neck, or one electrode may be applied to either nerve in the neck, and the other to the intercostal space nearest the attachments of the diaphragm upon the opposite side of the body. The latter course probably gives the best results, and when it is adopted the left side of the neck and the right side of the body should be selected, owing to the danger that in passing a current through the left side of the thorax an arrest of the movements of the heart may be caused by a possible diversion of the course of the electric fluid to that organ, this in anæsthetized animals, especially when chloroform has been employed, having frequently proved fatal.

The phrenic nerve in the neck is somewhat deeply seated, and the production of a direct impression upon it is rendered difficult by its dense covering of muscles and fascia. This difficulty can be best overcome at the point where the nerve crosses the scalenus anticus muscle; here it can be quite closely approached by pushing inward, toward the median line, the outer border of the sterno-cleido-mastoid muscle, beneath which it lies: by holding the muscle thus retracted, and at the same time pushing the electrode firmly in toward the nerve, a current through it can usually be established as soon as the other electrode is brought near the terminal filaments of the nerve distributed to the under surface of the diaphragm upon the opposite side of the body. Here the sixth or seventh intercostal space should be selected. Both electrodes should be small, and both tipped with sponges wet in water, hot when practicable, in order that the temperature of the body may be maintained. As soon as the circuit is established the diaphragm will be thrown into strong contraction. The completion of the circuit should be so timed that this contraction will take place simultaneously

with those movements of artificial respiration designed to promote inspiration; that is, when the walls of the chest are raised: by this means the calibre of the thorax will at the same moment be increased in all directions, the diaphragm being depressed and the ribs elevated concurrently as in normal respiration. If this rule is followed, the circuit will be broken when the ribs are compressed by the operator, and renewed when they are released from pressure. If Dr. Howard's method and directions are followed, this will occur at the rate of from seven to ten times in the minute.

Care should be taken to give to the current only a moderate degree of intensity. The normal movement of the diaphragm is gentle and rhythmical, and these qualities it is desirable, as far as is possible, to reproduce in the process of artificial stimulation of its functions. A fiercely energetic current will not only result in the fixation of the diaphragm in a tetanic spasm, entirely unlike its natural contractile movement, but will speedily exhaust both its nervous and muscular irritability, and so render all further movement impossible.

Electro-puncture.—This method for stimulation of the diaphragm has been recommended by various writers upon the subject, the course usually proposed being that of puncturing the skin over the lower intercostal spaces of either side with insulated electric needles, and passing the current through them instead of through the ordinary electrodes. Even the penetration of the diaphragm itself has been advised, and Dr. Alfred C. Garrett, in a work on medical electricity, gives the details of a case of resuscitation after prolonged immersion, in which he states that "long gold electro-puncture needles, well insulated except at the points, four in number and four inches in length each, were carefully inserted in quick succession some two or three inches apart along the front sides of the chest, two in the lower part of each pectoral, plunging them inward and downward between the fifth and sixth ribs their whole length, thus transfixing the pectoral, intercostal, and diaphragm muscles, embracing the external nerves, and also the solar plexus and the phrenic-nerve branches."

It need hardly be stated that such hazardous and extreme measures are not to be recommended for general adoption, and it may indeed be well doubted whether even the less formidable modes of electro-puncture are practically as efficient as the ordinary electrical stimulation through the unbroken cutaneous surface. That such stimulation is a highly valuable adjunct in the treatment of apnœa is unquestionable: it, however, should not be depended upon to the exclusion of other measures, and, above all, time should not be lost in waiting for the arrival or preparation of an electrical apparatus. Let it be used, if necessary, when ready, but until then there should be no cessation of effort to restore the patient by other agencies.

General Stimulation.—Attention has thus far been directed to methods for the stimulation of special functions; but in the mean time sight must not be lost of the necessity for the careful maintenance of the general vitality. By far the most important and reliable agent in the furtherance of this therapeutic indication is heat.

Heat.—This must, in any prolonged case of suspension of animation,

be persistently applied by such means as are most immediately available. Heated bricks or stones, bottles of hot water, the covers of a stove moderately hot, will answer if guarded from direct contact with the skin by a wrappage of cloths. With all such applications great care should be observed that they be not applied to the body of the patient at too high a temperature, as serious, and even fatal, burns may thus be occasioned. Relays of heated woollen cloths when they can be obtained answer even a better purpose if properly applied. The heat may be dry or the cloths may be dipped in hot water, the excess of moisture being wrung out before they are placed in contact with the body of the patient. As all such applications cool rapidly, they must be as frequently renewed. In all modes of stimulation by the application of heat to the cutaneous surface special attention must be directed to the extremities. When dry heated woollen cloths are used, the additional stimulus of friction may be imparted through their agency.

Friction.—This is a most valuable adjunct, and may be used to great advantage even without the application of artificial heat. Cloths and brushes may be employed, but a vigorous hand is more efficient than either. The friction should be brisk, but not so violent or so long continued in any one place as to produce abrasion of the skin. In executing the frictional movements the operator should endeavor to aid in the propulsion of the venous circulation from the periphery toward the heart, as the increased inflow of blood which may thus be secured will have a most important influence in stimulating that organ to renewed activity. By elevating the legs and arms gravity will favor the movement which the friction expedites.

Enemata.—As the margin of the anus and the rectum are among the last of the organs of the body to part with sensation in ether narcosis, stimulant injections may be introduced with a reasonable degree of probability that they will be efficacious in arousing dormant vitality by an excitatory impression upon the still sensitive surfaces with which they are brought in contact. *Enema terebinthinæ* (*U. S. P.*) (oil of turpentine, one fluidounce; mucilage of starch, fifteen fluidounces) may be used, or in the place of mucilage water may in an emergency be substituted; while instead of turpentine, water of ammonia may be employed in about the same proportions. In all cases the injection should be hot, so that if no other effect is produced temperature at least may be maintained. The enema should not be made too large, a gill being about all the rectum will hold without speedy expulsion.

Specific Stimulation.—Although the act of deglutition is often automatically performed even in advanced narcosis, still the introduction of stimulants into the stomach is a hazardous procedure, for with the muscles of deglutition at least partially paralyzed the patient cannot be trusted to swallow a dose placed in the mouth, as the stimulant would be quite as likely to run into the larynx as into the stomach, while, even if it reached that organ in safety, it could hardly enter the general circulation with sufficient celerity to be of any avail in the emergency under consideration. Hypodermic medication may be resorted to, but so far as whiskey and brandy are concerned, it may well be doubted whether alcoholism is not too closely allied to etherism to

render the former agent a proper antidote for narcosis by the latter: they are alike paralyzers of the respiration. The intravenous injection of ammonia has been recommended, but no signal success has attended its use, and the same may be said of the employment of such tetanizing agents as strychnia, picrotoxin, etc. In case of heart failure digitalis has been administered, but it is much too slow in its action to afford any immediate relief: atropia, hypodermically, is a much more prompt and efficient agent.

Peripheral Stimulation.—The application of ammonia vapor to the nostrils is a somewhat futile measure, as but little effect can be produced upon surfaces so fully narcotized. This remark, too, holds good with reference to the application of sinapisms, etc. to the general cutaneous surfaces. The irritant influence of such agents is due entirely to an impression made upon the superficial sentient nerves, and so long as they remain without functional power rubefacients, or even epispastics, are inoperative. This has been observed in the collapse of cholera, and is equally true of the depression of vital power and suspension of functional activity due to ether narcosis.

Secondary Effects of Etherization.—Headache, nausea, and vomiting, cough caused by bronchial irritation or pulmonary congestion, and in young and nervous females hysteria, are among the secondary effects which most frequently follow the inhalation of ether. In the vast majority of cases these effects will disappear in a short time without any interference on the part of the surgeon, but sometimes the sequelæ are so persistent and violent in character as to demand the adoption of active remedial measures.

Headache.—For the persistent headache following ether, as it is almost invariably associated with cerebral congestion, no local measure will be found more uniformly successful than the application of cloths wet with ice-water or of bladders filled with pounded ice to the general surface of the head, and especially the lower part of the occipital region. The cerebral depletion thus induced will be much promoted by hot applications to the feet, placing them in a vessel filled with water as hot as can be borne being, as a rule, the best and most convenient of these. When merely local measures fail, the use of bromide of potassium or of opiates may be resorted to. This latter treatment is best effected by hypodermic medication, one-sixth of a grain of the acetate of morphia being given at a dose and repeated according to indications. As cerebral congestion may be succeeded by acute inflammation, or, especially in aged persons, may terminate in paralysis or apoplexy, the use of active remedial measures should not be too long delayed.

Nausea after anæsthesia is so generally associated with headache, and even when this symptom is absent is so uniformly simply a sympathetic manifestation of cerebral disturbance, that measures for the relief of the latter condition will usually overcome the gastric irritability. Persistent nausea and vomiting, even when unaccompanied by headache, are often more effectually subdued by the hypodermic use of morphia than by any other treatment. Milder attacks, however, may generally be overcome by the use of local sedatives. Small pieces of ice swal-

lowed entire, or cold carbonic-acid water, or solution of citrate of ammonia given cold, have each proved efficacious. Benefit has sometimes been derived from the use of diluted hydrocyanic acid given in water in doses of a single drop; and the writer has had good results from the administration of single-drop doses of pure creasote made up into a pill with breadcrumb: both the hydrocyanic acid and the creasote appear to exert a local sedative or anæsthetic influence, and thus allay gastric irritability. When nausea and vomiting are violent and prolonged, persisting in spite of all remedial measures, the gravity of the situation must be recognized: such persistence not only saps the strength and vitality of the patient, but indicates serious disturbances in important nervous centres.

Cough.—The cough which is sometimes a troublesome sequela of etherization may be due to simple bronchial or laryngeal irritation, caused by contact with ether vapor; in which case it will, as a rule, disappear in a few hours without any special medication. This is the usual result, except with aged persons afflicted with emphysema or with chronic bronchial irritation or congestion, especially when the latter is due to those forms of valvular lesion which result in an undue accumulation of blood upon the venous side of the pulmonary circulation. Etherization in such cases may so intensify the congestion as to cause an almost complete occlusion of the air-vesicles, the patient slowly perishing from apnœa. In such cases of heart complication digitalis is always indicated: by the control which it exercises over the rate and duration of the diastolic and systolic movements of the heart less blood is sent to the venous side and more to the arterial side of the pulmonary as well as systemic circulation, thus relieving the stasis of blood in the pulmonary tissue. As adjuncts to this treatment stimulant expectorants, such as the carbonate or muriate of ammonium, may be administered, the strength of the patient being at the same time sustained by a diet of beef-tea and wine-whey. As a local application nothing is more effective than relays of hot-mush poultices, covering as much of the surface of the chest as possible.

Pulmonary Inflammation.—When the pulmonary congestion assumes the acute type and becomes a true pneumonia, such measures must be taken to control the violence of the inflammatory action as the conditions of the case indicate, quinine or opium, or such motor depressants as aconite and veratrum viride, being now the remedies usually resorted to.

Hysterical symptoms sometimes last for several days, but, as a rule, they speedily yield to valerian or other remedies of the "antispasmodic" group. Bromide of potassium also has been found efficacious, and frequently most prompt and satisfactory results have been obtained from the hypodermic injection of the acetate of morphia.

Etherization by the Rectum.

The rapid absorption of gases from the intestinal tract has suggested the practicability of producing systemic anæsthesia by the introduction

of ether vapor into the rectum. This method, according to Treves,[1] was first suggested in 1847 by Nikolaus Pirogoff in his work entitled *Rapport médicale d'un Voyage au Caucase*, published in St. Petersburg in 1849; but it was not until quite a recent period (1884) that the plan excited any particular attention. On March 21st of that year M. Daniel Mollière, surgeon of the Hôtel-Dieu at Lyons, at the suggestion of Dr. Axel Yverson of Copenhagen, operated on a young girl twenty years of age for a small tumor in the parotid region, the ether vapor being introduced into the rectum by means of a Richardson's atomizer. In this case complete anæsthesia was not produced until a small amount of the vapor had been administered by the respiratory tract.

M. Mollière's second patient was a woman forty years of age, operated on for a polypus in the antrum. In this case the bottle containing the ether was placed in hot water (50° C.) to vaporize it more rapidly, and then passed into the rectum through a rubber tube "the diameter of a finger." In this case, too, the inhalation of a small amount of ether was necessary. There was no nausea.

The method was tested in several other cases with results so much to the satisfaction of M. Mollière that he recommended it as a plan likely to be of great service in surgery, the advantages claimed being limitation of the period of excitation; reduction and more exact measurement of dosage; absence of respiratory irritation; and the fact that in operations upon the face or in the oral cavity the ordinary inhaling apparatus can be dispensed with.[2]

Since the above experiments were reported by M. Mollière the rectal method has been employed on quite a large number of cases, the apparatus generally used consisting of a wide-mouthed graduated bottle, the cork of which is perforated for the admission of two glass tubes, one of which is provided with a funnel for the introduction of the ether and a stopcock to prevent its escape. To the free end of the other glass tube is attached a piece of rubber tubing about two feet in length, the rectal end of this tubing being armed with the vaginal nozzle of a Davidson's syringe. In the bottle, which should have a capacity of about six ounces, two ounces of ether are placed, and the bottle immersed in a vessel containing water at a temperature of from 110° to 140° F. The ether at once boils, and, the rectal tube being introduced, the ether vapor passes into the intestine. As a considerable time, from fifteen minutes to half an hour, is required to produce full anæsthetic effects, a uniform temperature should be carefully maintained by the gradual introduction of additional quantities of hot water: either the cooling or the overheating of the ether is to be avoided, as the first retards and the second unduly and dangerously hastens the anæsthetic process.

That this method is not without its special dangers is unquestionable. M. A. Poncet,[3] after several experiments, warns the profession against it as having produced in some instances dilatation of the pupil and arrest of cardiac and respiratory movements. In one instance he states that the anæsthetic sleep was prolonged for two hours and a half after the operation, and for a period of twenty minutes he despaired of saving

[1] *The Year-Book of Treatment*, 1884.

[2] See *Lyon Médicale*, March, 1884.

[3] *Ibid.*, June, 1884.

the life of his patient. In this country one death has occurred, a child eight months old.

A very marked disadvantage of the process is the rapid distension of the colon which is sometimes produced, this not only causing considerable pain, but interfering to a dangerous extent with respiratory movements. When dangerous symptoms arise, it is difficult if not impossible to expel the ether vapor from the intestinal tract, its continued absorption from that surface increasing, of course, the hazard of the situation.

In a large percentage of cases distinctly irritant effects are produced by the local contact of the ether vapor with the mucous lining of the intestine. In nearly every instance diarrhœa has followed the employment of the method, and frequently the stools have been bloody. In one case "the patient's bowels were opened ten times during the night following the operation" (Treves). In a rabbit which died under rectal etherization the entire length of the intestine was found hyperæmic, and the large intestine greatly distended (Poncet).

It will thus be seen that etherization by the rectum is subject to serious disadvantages, and until these can be overcome it is a plan hardly to be recommended for general adoption, even in oral surgery, where, for convenience, such a method would be so desirable.

Chloroform.

Chemistry.—Chloroform was discovered by Soubeiran, the French chemist, in the year 1831. In the same year Liebig of Germany and Guthrie of Sackett's Harbor, N. Y., made independent discoveries of the same substance. The newly-discovered compound was called *ether bichlorique* by Soubeiran; Liebig regarded it as a trichloride of carbon, while Guthrie described it as a spirituous solution of chloric ether; but in 1835, Dumas discovered its true chemical constitution, and gave it the name under which it is now known.

There are several methods by which chloroform may be obtained: the process usually followed is the distillation of ethyl alcohol with chlorinated lime. Methyl instead of ethyl alcohol may be used, but the chloroform produced is unfit for anæsthetic purposes.

The exact details of the chemical changes resulting from this distillation have not been definitely determined. Neglecting the possible primary or sub-reactions involved in the process, such as the preliminary formation of an aldehyd (C_2H_4O), it may be stated in general terms that the principal change consists in the displacement of five atoms of hydrogen from the alcohol molecule (C_2H_6O) by chlorine, derived from the chlorinated lime, five chlorine atoms uniting with the displaced hydrogen to form five molecules of hydrochloric acid (5HCl), and three chlorine atoms uniting with the remaining portion of the alcohol molecule to form chloral (C_2HCl_3O); this molecule being itself immediately decomposed by a reaction with calcium hydrate, which, it is believed, is liberated from the chlorinated lime in the process, with the formation of chloroform and formate of calcium. The production of chloroform in this manner may be thus represented:

C_2H_6O	+	Cl_8	=	C_2HCl_3O	+	$5HCl$.
Alcohol.		Chlorine (from chlorinated lime).		Chloral.		Hydrochloric acid.
$2(C_2HCl_3O)$	+	$Ca2HO$	=	$Ca2CHO_2$	+	$2CHCl_3$.
Chloral.		Calcium hydrate (derived from chlorinated lime).		Calcium formate.		Chloroform.

As chlorinated lime (made by exposing slaked lime, CaH_2O_2, to the action of chlorine gas) is, as yet, an undetermined compound, any representation of its reaction with alcohol as an exact equation must be hypothetical. The essential facts are, however, as above represented.

The *National Dispensatory* (Stillé and Maisch) gives the following formulæ for the manufacture and purification of the drug:

"To prepare chloroform six parts of assayed chlorinated lime are mixed with about twenty-four parts of water, and the mixture strained into a still; one part of stronger alcohol is added, and the whole heated to 40° C. (122° F.), when the heat is nearly wholly withdrawn. The reaction now proceeds rapidly, the temperature rises, and the chloroform, mixed with some alcohol, distils over. The distillate is washed with water; the subsiding layer constitutes *crude chloroform.*

"*Purification.*—Take of commercial chloroform one hundred troyounces; sulphuric acid, twenty troyounces; stronger alcohol, twelve fluidrachms; carbonate of sodium, five troyounces; lime in coarse powder, half a troyounce; water, ten fluidounces. Add the acid to the chloroform, and shake them together occasionally during twenty-four hours. Separate the lighter liquid, and add to it the carbonate of sodium previously dissolved in the water; agitate the mixture thoroughly for half an hour, and set it aside; then separate the chloroform from the supernatant layer, and mix it with the alcohol. When the mixture has separated into two transparent layers, transfer the chloroform into a dry retort, add the lime and distil, by means of a water-bath, into a well-cooled receiver, taking care that the temperature in the retort does not rise above 67.2° C. (153° F.), until one troyounce of residue is left. Keep the distilled liquid in well-stopped bottles.—*U. S.*"

PROPERTIES.—Thus, refined chloroform is a limpid, colorless, volatile fluid, possessing a very sweet and pungent taste and an odor not unlike that of ether, but more aromatic and agreeable. Chloroform when as nearly as possible pure has a specific gravity of 1.5022. The specific gravity of the official chloroform of the *U. S. Pharmacopœia* is 1.480, this containing a little alcohol. Chloroform is not readily inflammable, but when ignited burns with a greenish, smoky flame. It is freely soluble in alcohol and ether, but only slightly soluble in water. Its own solvent powers are notable, many of the resins, the fixed and volatile oils and fats, camphor, gutta-percha, caoutchouc, such gums as benzoin, tolu, copal, and mastic—also bromine, iodine, and a large proportion of the organic alkaloids—being freely dissolved by it.

By exposure to air and sunlight chloroform is liable to undergo a slow decomposition, with the production of other combinations of chlorine, such as chloroxycarbonic or "phosgene" gas ($COCl_2$). As this is immediately decomposed in the presence of water, such a gas on entering the respiratory tract would doubtless be at once broken up into hydrochloric acid and carbonic acid ($COCl_2 + H_2O = 2HCl + CO_2$), thus forming a highly irrespirable mixture.

Tests.—*Acids and Chlorine.*—The presence of such products of decomposition may be determined by the action of the specimen upon moistened blue litmus-paper, which will be reddened by acids and bleached by free chlorine. Chlorine or hydrochloric acid, if present, will produce, with silver-nitrate solution, a white flocculent precipitate of silver chloride.

Alcohol and Ether.—The officinal chloroform contains, as already stated, a small proportion, about 1 per cent., of alcohol; and as this is found to give stability to the preparation and prevent the formation of acids, its presence in this amount is advantageous, and cannot, to any appreciable extent, affect the anæsthetic power of the drug. The existence of a more considerable quantity will of course proportionately lower the specific gravity, which should not be below 1.480. If the chloroform contains 2 or 3 per cent. of alcohol or ether, it will cause the coagulation of albumen; this a pure chloroform will not do.

Another test is to place a drop of the chloroform in a glass of clear distilled water: the globule will sink to the bottom and remain perfectly transparent if the specimen be pure, but will become opalescent if either alcohol or ether is present in the quantity above indicated.

Methyl Compounds.—These highly dangerous contaminations, so likely to be present when the chloroform has been distilled from methyl alcohol, may be detected by shaking the chloroform and an equal bulk of pure sulphuric acid together in an absolutely clean glass-stoppered bottle, and allowing the liquids to remain in contact for twenty-four hours. If at the expiration of this time no discoloration has appeared, the specimen may be pronounced free from methylated impurities; but the development of a dark-brown or blackish color stamps it as entirely unfit for use, except in the arts, in many of which chloroform made from wood-spirit is largely consumed.

Deterioration.—Under the combined influences of sunlight and air even the best specimens of chloroform are liable in the course of time to become contaminated by the products of decomposition. To guard against this result to as great an extent as possible, the chloroform should be kept in a bottle well filled, and tightly corked to exclude air and prevent waste: this a glass stopper, unless fitted with more than ordinary nicety, accomplishes very imperfectly. When the specimen is to be kept on hand for a very long time, the bottle should be placed in dark wrappings in a dark closet to exclude light. The drug if very old should never be used without careful tests as to its purity.

Vaporization.—Chloroform is an exceedingly volatile substance, but, like other agents of its class, vaporizes much more rapidly at an elevated than at a low temperature.

Snow found that at 40° F. air would take up but 6 per cent. of chloroform vapor; at 50° F., 8 per cent.; at 60° F., 12 per cent.; at 70° F., 19 per cent.; at 80° F., 26 per cent.; and at 90° F., 35 per cent. Hence, as with ether, anæsthetic effects are produced far more quickly in a warm room than in a cold one. The vapor is more than four times as heavy as atmospheric air, and has a specific gravity of 42 at 60° F. (Snow).

Physiological Effects.—*Given by the stomach,* in medicinal doses

(♏ij–♏v), taken shaken up with water or dropped upon sugar, chloroform produces simply a feeling of gentle warmth, followed by the coolness consequent upon its rapid vaporization, but when swallowed in very large doses, undiluted, it acts as a violent irritant as well as narcotic poison. The result, however, is not invariably fatal. Taylor reports a case[1] in which a man swallowed four ounces of chloroform and yet recovered. He was able to walk a considerable distance after taking the dose, but subsequently fell into a state of coma, with dilated pupils, stertorous breathing, cold skin, imperceptible pulse, and general convulsions. Recovery followed after five days.

In the case of a physician who swallowed three ounces of the drug the result was not so favorable: complete anæsthesia continued for fourteen hours; this was followed by a return to consciousness, but acute gastritis and rapid collapse ensued, the patient dying in twenty-four hours after taking the poison.

Much smaller doses, however, have caused alarming depression, and Taylor[2] reports the case of a boy four years old in whom fatal coma was caused by a single drachm of the drug. Anstie found that forty-five minims produced decidedly anæsthetic effects upon himself: this amount he took suspended in an ounce and a half of thin mucilage, "the stomach being quite empty at the time." He states that—

> "Great warmth at the epigastrium and a feeling of flushing all over the body succeeded, almost at once, five minutes after taking the dose; the pulse was throbbing 100 per minute, and the heart beating with uncomfortable violence; a sense of decided confusion of mind also annoyed me. Five minutes later I experienced a considerable degree of nausea, and the pulse had fallen much lower, but it was impossible for me to speak as to its positive frequency, as I must have fallen very soon after this into a state of unconsciousness. I recovered my senses at length, and on looking at my watch found that it was forty-six minutes from the time of commencing the experiment. That it was not common sleep into which I had fallen was obvious from the fact that my lower limbs still felt heavy and numb, and on attempting to stand I tumbled down. For almost two hours after this I remained in a state of great discomfort, shivering, nauseated, and with aching pains in the head and in all my limbs, which sometimes assumed the sharpness of a twinge of neuralgia. It was some time also before I recovered my muscular sense and an accurate co-ordinating power over the movements of the limbs."[3]

There is no true chemical antidote for chloroform taken in toxic doses: artificial respiration, heat, and faradization must be resorted to, as in anæsthesia by inhalation.

Hypodermic medication with chloroform is sometimes practised, and is highly recommended by Bartholow, who was the first to propose its use in the treatment of neuralgia. His plan of treatment consists in the injection deeply in the neighborhood of the affected nerve of five to fifteen minims of pure chloroform. Prof. Bartholow states that "considerable pain is produced by this injection: swelling of the invaded tissues follows, and a circumscribed induration and numbness are left;

[1] Taylor on *Poisons*, p. 619. [2] *Op. cit.*, p. 740.
[3] *Stimulants and Narcotics*, p. 310.

but these effects slowly disappear. An abscess may result from local inflammation, but this is not frequently the case. The author has procured by this means apparently permanent relief to long-standing cases of neuralgic pain (tic douloureux) affecting the superficial divisions of the fifth. Other practitioners have been equally successful, and the cases thus treated now include neuralgic affections of the most important nerves."[1]

Upon the skin, unless very delicate, the local effect of chloroform is not so irritant as upon mucous and subdermal surfaces; indeed, an irritant effect is not usually produced unless close contact of the fluid is maintained and vaporization is retarded or prevented. With these precautions, which may be effected by covering the skin in contact with the chloroform with some impermeable fabric, such as rubber cloth or oiled silk, good counter-irritant and slightly anæsthetic effects may be obtained. For a small area of tissue a thimble placed over the chloroform will confine the vapor and so obtund sensation that a slight puncture may be made without pain. Where more decidedly counter-irritant effects are desired the writer has for many years used a combination of chloroform, ammonia, and alcohol after the following formula:

℞. Chloroformi,
Aquæ ammoniæ fort., *āā*, f℥j;
Alcoholis, f℥iv. M.

Sig. For external application.

This makes an excellent combination: it does not stain either the person or the clothing, and is free from objectionable odor. The vapor is often grateful in headache, and the forehead or other seats of pain may be bathed in the fluid, while by confining the vapor any degree of counter-irritation may be induced, from the mildest rubefacient effect to the formation of a blister, the result being regulated by the length of time during which the escape of vapor is prevented. Thus applied, it will often be found a convenient, cleanly, and efficient substitute for a mustard plaster.

Effects by Inhalation.—The effects of chloroform vapor when inhaled are very closely analogous to those produced by the inhalation of ether. It is probable that concentrated chloroform vapor is even more irritant to the pharyngo-laryngeal tract than ether vapor at the same tension and in the same volume. This was evidenced in the experiments of the committee appointed by the Royal Medical and Chirurgical Society to investigate the effects of chloroform, and who found that air saturated with chloroform when breathed by animals produced contraction of the entire pharynx and violent and repeated acts of deglutition, while when a 5-per-cent. dilution of the vapor was blown upon the fauces no irritant effect was produced, and that after partial insensibility of the fauces was thus effected the more concentrated vapor might be inhaled without the spasmodic movements described.

Concentrated vapor is, however, dangerous at any stage of the process, the committee having observed a diminution in blood-pressure each time additional chloroform was placed in the inhaler. Heart

[1] Bartholow's *Materia Medica and Therapeutics*, p. 358.

paralysis, as the result of impressions thus made upon the laryngeal nerves, or upon the terminal branches of the pneumogastric distributed to the lungs, is now recognized as one of the most frequent causes of death in chloroform narcosis, although the specifically depressing influence of the drug upon the cardiac ganglia is doubtless an important attendant condition in such cases.[1]

Authorities differ as to the relative frequency with which vomiting occurs during anæsthesia produced by ether and chloroform respectively. Kappeler gives a result of 14 per cent. in chloroform narcosis and 25 per cent. in ether narcosis; and this perhaps fairly well represents the proportion. In the writer's experience, however, vomiting after return to consciousness—generally a much graver and more troublesome complication—occurs more frequently with chloroform than with ether; and this accords with the observation of Dr. Thomas Keith, who was led to try ether instead of chloroform in ovariotomy, and states that "whereas with chloroform vomiting was the general rule, it now seldom occurs in his practice."[2]

Chloroform, like ether, produces progressive paralysis of the nervous centres controlling intellection, movement, voluntary and involuntary, and special and general sensation. With chloroform complete narcosis is more rapidly induced than with ether, but as the great nervous tracts are narcotized in the same order and with the same symptomatic manifestations, no other very marked differentiation between the usual effects respectively of the two agents can be distinguished. A paramount point of distinction, now universally conceded, is that when chloroform is used the cardiac ganglia are far more likely to undergo paralysis than when ether is the agent employed.

Preparation of the Patient.—The details concerning the preparation of the patient, etc., already given in connection with the subject of etherization, are all applicable to the production of the anæsthetic condition by means of chloroform. No single precaution should be omitted; indeed, as chloroform is by far the more potent and dangerous drug, the care and vigilance of the operator should be redoubled; above all, as failure of the circulation is the chief danger, the reclining position must be insisted upon. Owing to the irritant effect upon delicate cutaneous surfaces of chloroform when contact is close and constant, the face of the patient, especially about the mouth and nose, should be anointed with some fatty substance as a protective shield.

Preliminary Medication.—The administration of opiates to the patient previous to the inhalation of chloroform is now the usual practice of a majority of those who rely upon that anæsthetic agent. Nussbaum of Munich in 1863 was the first to call general attention to the value of the hypodermic administration of morphia as a means of prolonging the anæsthetic state without increasing its dangers. The experiments of Claude Bernard upon the lower animals also demonstrated the fact that some of the more undesirable features of a purely chloroform narcosis were antagonized by this preliminary hypodermic injection, the two

[1] Dr. Reeve (*American Journ. Med. Sci.*, Jan., 1867) was the first to call attention to this element of danger in the administration of chloroform.
[2] Holmes's *System of Surgery*, vol. iii. p. 549.

agents appearing to be supplementary in their effects, so that a more profound and prolonged sedation could be produced with a much smaller amount of chloroform than is usually required when that agent is employed alone. In regard to its use upon the human subject, Dr. Reeve[1] makes the following statement: "Given hypodermically to the amount of from one-sixth to one-third of a grain some twenty minutes before the inhalation of chloroform, it diminishes the stage of excitement, lessens to one-half, or even one-third, the amount of the anæsthetic required, diminishes the vomiting, and promotes quiet sleep afterward. . . . . The value of this plan may be said to be now generally recognized, particularly for protracted and severe operations. It should never be omitted in cases where great dread of the operation exists, producing an emotional state which experience has shown to have played no insignificant part in the history of chloroform accidents. Tranquillized and soothed by the narcotic, such patients pass quietly into the anæsthetic state, and certainly escape risks otherwise encountered."

Prof. Gross states[2] that "this practice" (the use of opiates) "has long been in force in all my more severe clinical cases, and I have the greatest confidence in its efficacy, not only in sustaining the heart's action, which the different preparations of opium are so well known to do, but in preventing the cough, excitement, and muscular rigidity so often witnessed, especially in nervous persons."

As one of the primary physiological effects of opium and its principal alkaloid is to strengthen the action of the heart, this action continuing during a period of time relatively quite considerable—a period certainly exceeding that required for the completion of the average operation—its use in connection with chloroform would seem to be indicated on physiological grounds as well as warranted by the results of practical experience. Of recent years a combination of morphia and atropia, administered hypodermically, has been thought to produce even better results than morphia alone, the atropia, as is claimed, antagonizing far more effectually than does the opium alkaloid the inhibitory influence exerted by the pneumogastric nerve when stimulated either by shock or by the specific excitatory influence exerted by all volatile anæsthetics; to which influence the frequent vomiting and occasional cardiac arrest following their administration are by some attributed. The dose of atropia recommended is from $\frac{1}{180}$th to $\frac{1}{90}$th of a grain, to be given in combination with from $\frac{1}{12}$th to $\frac{1}{6}$th of a grain of morphia, within from about twenty to thirty minutes before the administration of the anæsthetic.

This combination has been recommended for use before ether as well as chloroform inhalations, but as the action of the heart is, as a rule, not seriously weakened by the former agent, theoretically such a combination would not seem to be demanded; neither has the fatality which has hitherto attended the use of ether been so great as to make imperative any very radical changes in existing methods for its administration.

A strong argument against unnecessary complications in anæsthesia

[1] "Anæsthetics," Holmes's *System of Surgery*, pp. 555, 556.

[2] *System of Surgery*, p. 559.

is the fact, which all practical medical men must recognize, that by a multiplication of pharmaco-dynamic influences in the giving of anæsthetics, as in medication for disease, symptoms are often obscured, masked, or confused, to the embarrassment of the surgeon or physician and the danger of the patient. Untoward manifestations attending the use of a single toxic agent, when the modes by which its properties are manifested and the direction in which its force is expended are clearly understood, may be antagonized much more readily and with much greater assurance of success than when many such potencies, assailing by as many different lines of attack, are to be met and overcome. Ether may at some future time be made even safer than it now is, but it may be unhesitatingly affirmed that that result has not been accomplished by any anæsthetic combination yet devised. Chloroform might well be made less dangerous, and that combinations with morphia or atropia, singly or together, are means to this end would seem to be the general verdict of those who practise those forms of mixed anæsthesia.

The administration of alcoholic stimulants previous to chloroform narcosis is also highly commended by many; and as alcohol, for a time at least, except in excessive doses, stimulates cardiac action, its use, too, would appear to be theoretically correct. For this form of stimulation brandy or whiskey is usually given, in doses of from half a fluidounce to two fluidounces, diluted, about ten minutes before the administration of the anæsthetic begins.

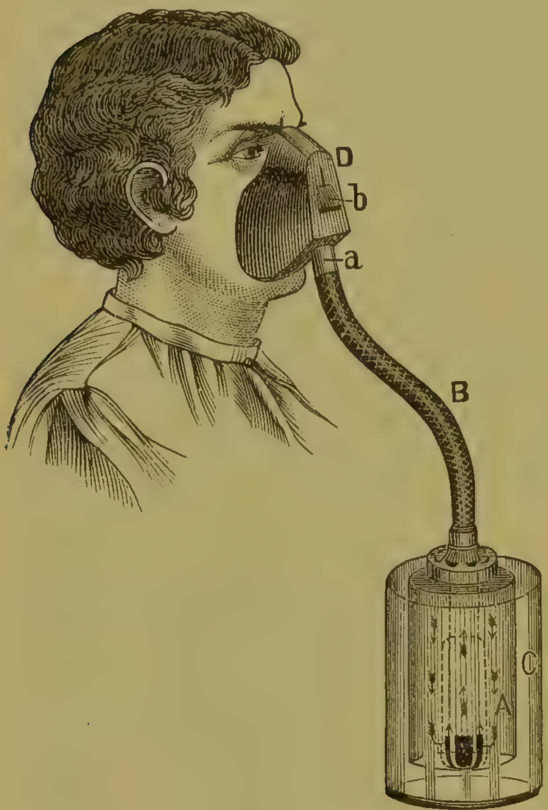
Mode of Administration.—*Inhalers.*—As chloroform is a drug of great potency, its vapor can be safely inhaled only when largely diluted with air. At 70° F. air, as has been seen, is capable of holding in suspension 19 per cent. of chloroform vapor—a proportion much too large for anæsthetic purposes, from $3\frac{1}{2}$ to 4 per cent. being found to give the best results. To secure and maintain this exact dilution is a matter of no small difficulty, and a large number of inhalers have been introduced for this purpose. That of Dr. Snow was probably the first to be devised and used.

Snow's Inhaler.—Snow's inhaler consisted of a mouthpiece or mask provided with valves, the mask communicating by tubing about a foot long and three-quarters of an inch in diameter with an apparatus in which the air became charged with chloroform vapor by passing over and through coils of bibulous paper wet with the drug, the temperature of the vapor being regulated by a water-bath, which was a part of the appliance. This apparatus is figured by Snow in his work on anæsthetics (p. 82). A better illustration, however, is that seen in Fig. 8.[1] The inhaler consists of double cylinders of metal, the outer of which (C) contains water at the ordinary temperature of the room, the purpose of this being to prevent that cooling of the entire apparatus which would otherwise result from the vaporization of the chloroform, such a reduction in temperature being undesirable, owing to the retarding influence it would exert upon the evaporation of the anæsthetic. The inner cylinder (A) is the vaporizing chamber. Within it there is screwed a frame provided with numerous openings for the admission of air and having four stout wires which descend nearly to the bottom of the cylinder. These

[1] From Kappeler, *Anæsthetica*, p. 140.

wires are for the support of two coils of bibulous paper, which are tied around them and reach fully to the floor of the cylinder. In the lower part of these coils of paper four notches are cut to allow the air to pass in the direction indicated by the arrows; that is, through the openings seen in the top of the cylinder outside of the paper coils, then beneath them, through the four notches, then upward inside the paper coils, saturated with chloroform, to and through the elastic tube (B) communicating with the mouthpiece (D).

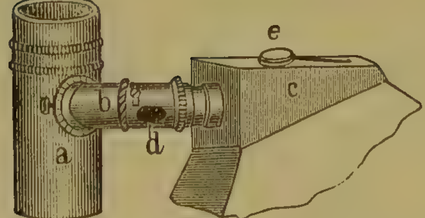
FIG. 8.



The chloroform to be vaporized, about two and a half fluid-drachms, is placed in the bottom of the cylinder. Care should be taken not to introduce enough of the fluid to fill the notches cut in the paper coils for the transmission of air. Kappeler recommends that a layer of bibulous paper be placed also in the bottom of the cylinder; which is a good suggestion, as thereby the chloroform would be more fully and readily absorbed, and its vaporization be thus more gradually and equably effected.

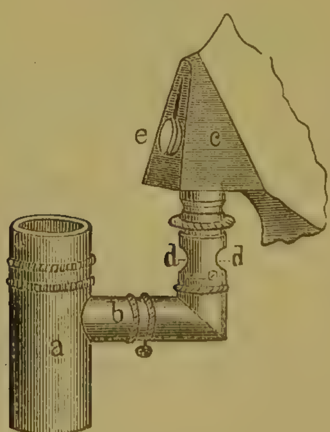
The mouthpiece represented in the cut is the invention of Dr. Francis Sibson. It was originally made of some pliant material, such as leather or sheet lead, although if now used flexible rubber would probably be employed. It contains two valves: one of them is placed at its point of connection (a) with the elastic tube. This valve opens during inspi-

FIG. 9.



Sansom's Inhaler adapted to the recumbent position.

FIG. 10.



Sansom's Inhaler adapted to the sitting position.

ration and closes during expiration. The second valve (*b*) is in front of the mouthpiece, and opens during expiration and closes during inspiration.

During the earlier stages of the administration of chloroform by this inhaler the expiration valve (*b*) can be held partly open, thus permitting the entrance of pure atmospheric air and diluting to any required extent the chloroform vapor passing from the inhaler through the inspiration valve (*a*). Dr. Snow claimed that with this inhaler air at the ordinary temperature of about 60° F. would take up about 5 per cent. of chloroform vapor.

Sansom's Inhaler.—The inhaler of Dr. Snow proving in practice to be somewhat cumbersome and othewise unsatisfactory, Dr. Arthur Earnest Sansom devised the more convenient apparatus represented in Figs. 9 and 10. The construction and mode of using this inhaler are thus described by Dr. Sansom:[1]

"The receptacle for the chloroform is a small metallic cylinder, its height about three inches, its diameter about an inch and a half. It is filled with blotting-paper loosely crumpled, or, what is better, a rolled piece of lint; at the top it is provided with a freely-perforated plate for the admission of air and for the introduction of liquid chloroform. An exit-tube passes at right angles from this receptacle, it being attached a little above the centre, so that a cup may be kept for the retention of any liquid chloroform which may be more than sufficient to moisten the blotting-paper or lint. Thus arranged, a direct current of air in inspiration passes through the apertures over the chloroform, and of course carries the vapor along with it.

"The next requisite was to supply an equality of temperature. I found this object fulfilled sufficiently for all practical purposes by surrounding the metallic cylinder with a stratum of gutta-percha. I found that a cylinder of equal size with that of Dr. Snow's cylinder, and surrounded with gutta-percha as Dr. Snow's is with water, allowed even a greater percentage of vapor to be given off than the latter did. Thus in my experiments after twenty inspirations in case of the cylinder surrounded with water, 30.04 cubic inches of vapor passed; in case of the cylinder surrounded with gutta-percha, 36.4 cubic inches passed.

"But, as I have before said, the difficulty is not so much in keeping up this high proportion as in preserving it sufficiently low. I fulfilled the indication of diminishing the proportion by reducing the cylinder in size and bulk; and I was led to consider that the value of the gutta-percha was not so much to keep the chloroform warm, as it were, but rather to prevent the metallic surface from getting too warm from being held in a hot hand.

"It was thought much more convenient to abolish the long flexible tube. The exigencies of mobility were to be provided for; a very simple arrangement accomplished this. The exit-tube was again bent at a right angle before ending at the mouthpiece. Thus the instrument was adapted to a patient in the sitting position, and the tube being freely movable at the place of adaptation of the mouthpiece, the cylinder could be turned to the right or left as required. To make the whole instrument adapted to the recumbent position, it was only necessary to make provision for a rotatory movement in the horizontal part of the exit-tube. Thus the chloroform-containing cylinder could be always retained upright. There was no

[1] *Chloroform, its Action and Administration*, pp. 188–191.

necessity for a flexible tube; for by the double movement of the receptacle on the exit-tube and of this tube on the facepiece any position was provided for. The receptacle was always preserved upright, so that no chloroform could be spilled, and any movement of the patient, however brisk, could be followed in a moment.

"In that part of the tube which terminated in the facepiece I caused to be introduced an arrangement by which a supply of air could be turned on or cut off at pleasure. The tube here is double, an external rotating upon an internal: both are perforated, front and back. Thus in one position air enters freely; by slightly turning the outer tube the apertures are partially closed, and by turning it still more they are covered completely; the unperforated portions of one tube cover the perforations of the other.

"The facepiece is the same as Dr. Sibson's, but it freely turns upon the tube of the inhaler.

"The receptacle being supplied with blotting-paper or lint, and a little piece being also laid along the horizontal part of the tube so as to act as a siphon, a drachm and a half of chloroform is poured into it. This quantity is usually sufficient, as there is so little waste. The outer movable tube near the facepiece is so turned that the holes in it are coincident with the holes of the inside tube; consequently, unimpeded currents of air enter. Moreover, the valve of the facepiece is turned away from its aperture. The patient, being now allowed to inhale, breathes so much atmospheric air that the taste of chloroform barely reaches him. The outer tube is then turned so as to cut off in a slight degree the entrance of air, and this is done every two or three inspirations, until, the apertures being closed, no air enters by these channels. Still, the aperture of the facepiece allows the entry of air. This expiratory valve being made gradually to cover its aperture, the patient breathes a sufficient proportion of chloroform perfectly to induce anæsthesia.

"The process is thus a gradual one from the beginning until such time as the patient is able to breathe an atmosphere of 5 per cent. There is no cough, no struggling, no resistance, but the patient succumbs to the chloroform sleep gradually and imperceptibly."

Clover's Inhaling Apparatus.—The late Mr. Clover of England, realizing the desirability of securing for inhalation a fixed and definite dilution of the chloroform vapor in atmospheric air, reintroduced a method first suggested and tried by Dr. Snow, that of introducing into a bag or balloon of known size a measured quantity of chloroform, filling the balloon with air, and allowing the patient to inhale from it through a mouthpiece provided with a valve to prevent the return into the balloon of the products of expiration. In regard to this method Dr. Snow says:[1]

"I tried this plan in a few cases in 1849, with so much chloroform in the balloon as produced 4 per cent. of vapor in proportion to the air. The effects were extremely uniform, the patients becoming insensible in three or four minutes, according to the greater or less freedom of respiration; and the vapor was easily breathed, owing to its being so equally mixed with air. I did not try, however, to introduce this plan into general use, as the balloon would sometimes have been in the way of the surgeon, and filling it with the bellows would have occasioned a little trouble. It seemed

[1] *Anæsthetics*, p. 80.

necessary to sacrifice a little of absolute perfection to convenience, and I therefore continued the plan I had already followed."

The apparatus used by Mr. Clover is represented in Fig. 11, and is thus described by Dr. Sansom:[1]

FIG. 11.

Clover's Inhaling Apparatus.

"The apparatus he employs is, first, a bag for containing the anæsthetic mixture; secondly, an arrangement for filling the bag with a certain proportion of chloroform and air. The bag is of a large size, capable of containing sufficient of the chloroform atmosphere to serve for several cases of inhalation. It is lined with a film of a material (such as goldbeater's skin) which is capable of resisting the solvent action of chloroform. A flexible tube leads from the bag to the mouthpiece, which is of the same conformation as Dr. Sibson's; but Mr. Clover has introduced an improvement by using for the valves thin plates of ivory supported by spiral springs. The india-rubber which is usually employed for the valves is apt to curl up.

"The apparatus for filling the bag with the atmosphere for inhalation consists of a bellows shaped like a concertina, with a receptacle for a definite amount of chloroform attached to its nozzle. This receptacle is a metallic box, which is kept warm by an interstratum of hot water, so as to facilitate the evaporation of the chloroform, which is received on blotting-paper in its interior. The lid of the box contains an aperture for the reception of a graduated syringe, by which the chloroform is supplied. Opposite

[1] *Op. cit.*, pp. 179–182.

that part of the box to which the nozzle of the bellows is attached is an open tube, to which the bag can be adapted. The apparatus being thus connected, air is blown over the chloroform into the bag by means of the bellows. For each thousand cubic inches of air which the bellows throws in, forty minims of chloroform are supplied by means of the syringe. Thus, since forty minims of chloroform produce about forty-five cubic inches of vapor, the atmosphere in the bag contains 4½ per cent. of chloroform vapor. Of course the percentage is determined at will by the amount of chloroform supplied.

"When sufficient of the atmosphere has been thus prepared, the bag is detached from the metallic box and the mouthpiece applied. It is then suspended in a convenient position from the collar of the administrator's coat. The position of administrator and patient is seen in the engraving (Fig. 11).

"In commencing the inhalation free air is introduced by an aperture (near the facepiece) which can be gradually closed as the patient becomes accustomed to the vapor.

"I consider this to be the safest method of all for the administration of chloroform. Mr. Clover in a letter to myself states, 'I have found my inhaler produce the anæsthesia more uniformly than I have been able to effect by any other means. Patients very rarely cough or make any manifestation of the vapor being too pungent. A large majority of the patients are prepared for the commencement of the operation in less than six minutes, and they certainly recover from the effects of chloroform more readily and with less sickness and prostration than I have observed when I did not make use of the inhaler.'

"For myself, speaking theoretically, I believe that this means obviates the most urgent objection to chloroform administration, and is especially useful when patients are assembled together ready to be operated on one after another. The most potent objections to it are the somewhat cumbrousness of the reservoir, the necessity of employing some little time in making the mechanical arrangements for the production of the atmosphere, and, lastly, the expensiveness of the apparatus. Though of great value to those who are accustomed to administer chloroform, it is scarcely to be expected that every practitioner would provide himself with an apparatus of this sort."

Paul Bert's Method.—What was practically the same method as that of Snow and Clover was subsequently adopted by the late Prof. Paul Bert of Paris, who in 1883 called the attention of the Biological Society of that city to a method of anæsthesia by chloroform which to him appeared to possess absolute security.

The following is Prof. Bert's account of his experiments with the method upon animals:[1]

"I commence by putting an animal rapidly to sleep with a mixture of twelve grammes of chloroform vaporized in one hundred liters of air. Anæsthesia is produced very rapidly and almost without reaction. Then by opening a stopcock I cause the dog to breathe a mixture consisting of eight grammes of chloroform in one hundred liters of air. This mixture, which if used alone would have produced the anæsthetic sleep very slowly and imperfectly, serves to maintain the insensibility secured by the stronger mixture. I have thus been able to keep dogs insensible during three hours

[1] See *Comptes rendus des Séances et Mémoires de la Société de Biologie*, séance du 16 Juin, 1883.

and a half without any trouble with the respiration or circulation. With twelve grammes for one hundred liters of air they would be dead in about an hour and a half.

"This very simple method, which requires for apparatus only two sacks of caoutchouc, to me appears at the same time very harmless and very easy to put in practice."

Six months later, in a communication to the Biological Society,[1] M. Bert announced the successful application of his method to the human subject. In this communication he says:

"The first application of the method was made December 21, at the Hôpital Saint Louis, during the service of Dr. Péan. The experiment was conducted by Dr. Dubois, assistant in my laboratory. It succeeded perfectly. The mixture of eight grammes of chloroform in one hundred liters of air has from the first given excellent results. . . . . In one case anæsthesia was continued during twenty-eight minutes, during which only fifteen grammes of chloroform were used. . . . . The mixture of eight in one hundred is very readily tolerated: the resistance which is ordinarily offered by patients to the inhalation of anæsthetic vapors was not made. The state of dilution of the vapor shielded from irritation the nerves of sensation in the respiratory passages: there was no cough, no spasm, no suffocation, no spasm of the diaphragm, or efforts at vomiting in the early stages of the inhalation. Two of the patients had eaten before the operation, but they had only a few qualms of nausea after its completion.

"The anæsthesia is regular in its progression: if a longer time is required than where the more concentrated vapor is used, there is not the preliminary period of violent agitation ordinarily observed. Finally, the patient after the cessation of the inhalation remains asleep during a period of time sufficient to effect the painless dressing of the wound: the awakening is always calm, sometimes gay.

"As to the economy of the process, the quantity of chloroform required is much less than by ordinary methods, an average of from fifteen to twenty grammes being used in operations of from fifteen to twenty minutes' duration. The vapors which spread around the patient are much less disagreeable than those which escape from the inhaler in the old process."

Dr. A. Aubean[2] states that up to February, 1885, two hundred patients had been operated upon during the service of Dr. Péan in the Hôpital Saint Louis, with results confirming the value of the method. According to the same authority, Prof. Bert subsequently somewhat modified the proportions of his mixture by beginning with ten grammes of chloroform in one hundred liters of air, and when anæsthesia was complete giving eight in one hundred, afterward maintaining the anæsthetic state by a mixture containing six grammes in one hundred.

Several changes also were made in the combining and inhaling apparatus. The sacks of caoutchouc were replaced by a device of Dr. Saint Martin, which consisted of two gasometers, one of which was filled while the patient inhaled from the other. Two assistants were required for its management. For this reason, and because the tubes and valves were liable to get out of order, "constituting a permanent danger," Dr.

[1] Séance du 22 Decembre, 1883: "Application à l'Homme de la Méthode d'Anæsthesie chloroformique par les Mélanges titrés."

[2] *L'Odontologie*, Février, 1885.

Raphael Dubois substituted for it a contrivance of his own, consisting of two telescopic gasometers, each with a capacity of a hundred liters, one assistant being sufficient for their operation. This too was found unsatisfactory and unreliable, and Dr. Dubois had constructed the appa-

FIG. 12.

Anæsthetic Apparatus of Dr. Dubois.

ratus represented in Fig. 12, in which gasometers were entirely dispensed with, and of which he gives the following description:[1]

"The anæsthetic machine consists of an air-pump, recalling the form known in hydraulics under the name 'pompes des prêtrés.' A horizontal circular plate supporting an invaginated membrane is put in movement through the action of a shaft terminated at its upper part by a Vaucanson chain reflected over a toothed wheel and supporting at its free extremity a counterweight.

"This toothed wheel is put in movement by a cog-wheel to which is communicated an alternate circular movement, limited in each direction by an attachment controlling at each end of the course a slide-valve similar to those used in steam-engines, thus avoiding the use of valves self-acting under pressure, whose action is often imperfect, and, as a consequence, disquieting.

"The working of this part of the mechanism is invariably given to the person to whom is entrusted the measurement of the dose of the liquid anæsthetic. To this end a small perforated metallic vessel, operating like a *godet de noria*, passes at each stroke of the piston the desired quantity of the anæsthetic employed into a receptacle placed beneath it. The *godet*,

[1] *L'Odontologie*, August, 1884.

having arrived at the culminating point of its course, empties its contents into a mixing-chamber traversed by the air drawn from the exterior by the movement of the piston.

"The volume of air, measured by the capacity of the body of the pump, is always sufficient to volatilize completely the liquid anæsthetic, the vapors of which mix intimately with the air at the moment of its passage into the mixing-chamber.

"The air-pump has a double action: thus the apparatus may be charged upon one side of the piston, while upon the other side the prepared mixture is conducted to the respiratory passages of the patient by a flexible tube, to which may be adapted either a mask made after a special model, without valves, or, if desired, a tube through which the anæsthetic mixture may be injected into the back part of the mouth."

Still further details in regard to this apparatus are given in *L'Odontologie*,[1] as follows:

"As one turn of the crank corresponds to the introduction of about twenty liters of air, it will be seen that in a majority of cases the crank may be turned quite slowly; after several turns have been made a sense of resistance will be felt, due to the fact that the piston has terminated its course. The crank is then turned in the opposite direction, so that the two faces of the piston may be alternately evacuated; in each movement the termination of the course is indicated by a very sensible resistance.

"All the other functions of the machine—placing of the chloroform, dosage, distribution of the mélange upon the two faces of the piston, etc.—are entirely automatic, and invariably dependent upon the movement of the crank. . . . .

"The inhaler is made in two different forms, the one to be used when the anæsthetic mixture is to be inhaled in the ordinary manner, the other available when it is desirable to deliver the anæsthetic into the back part of the buccal cavity or pass it through the naso-pharyngeal passages, as may be done in operations in the mouth or upon the face.

"In such cases this apparatus renders very great service, for its use makes possible the injection of the exactly proportioned anæsthetic mixture directly into the bronchial passages, and the maintenance of an anæsthesia more profound and continuous than can be obtained by any other method. The mixture is carried to any desired distance by means of a special metal tube which accompanies each machine, and which may at the same time play the part of a tongue-depressor and prop for keeping the jaws apart. . . . .

"The inhaling mask has no valves: it is so arranged that the patient always remains in the presence of a definitely proportioned anæsthetic atmosphere, in which he can respire as freely as under ordinary conditions. An accident happening to the machine or inhaling-tube could result in no other possible inconvenience than the patient's deprivation of the anæsthetic mixture: he could still breathe freely by means of the orifice through which he expires when the machine is in movement, and which at all other times remains open."

Merits of Inhalers.—As to the practical merits of either the Clover apparatus or that of Dr. Dubois the writer has had no opportunity of determining by personal observation; but concerning the value of the

[1] February 1885, pp. 59–61.

principle of the definite dilution of chloroform vapor which they are designed to secure there can be no question; for, as has been previously stated, it has been fully demonstrated, both by unfortunate clinical experience and by physiological experimentation, that concentrated chloroform vapor either in the early or later stages of anæsthesia is capable of producing not only spasm of the glottis, but paralysis of the heart by the sudden irritation of the branches of the par vagum in the lungs.

Sansom[1] remarks on this point: "I recognize two principles for attaining the maximum of safety in chloroform administration:

"I. The continuous inhalation of an atmosphere of known strength—an atmosphere of about 3½ per cent. We may call this the principle of definite dilution.

"II. The administration of an extremely dilute atmosphere at first, and the progressive increase in its strength, never overpassing 5 per cent. We may call this the principle of tolerance."

Dr. Snow[2] says that "if there be too much vapor of chloroform in the air the patient breathes, it may cause sudden death, even without previous insensibility and while the blood in the lungs is of a florid color."

As without some such apparatus as that either of Clover or Dubois it is practically impossible to maintain a perfectly definite and uniform dilution of chloroform vapor in the atmospheric air inhaled by a patient, it would seem to be but the part of common prudence to throw around the administration of the drug all possible safeguards, and not allow the desire to save "a little trouble," which Dr. Snow states (see p. 115) was his only reason for sacrificing "a little of absolute perfection to convenience," to weigh against considerations of safety for the patient.

The fact that the inhaling mask attached to the vaporizing-machine of Dr. Dubois is without valves is much in its favor, as their disarrangement is always among the possibilities and has frequently led to serious consequences.

The frequent occurrence of such accidents, and the numerous deaths which have followed the administration of chloroform even when given in exact and correct dilution, have created prejudices which in this country at least have led to the almost entire abandonment of any apparatus of the kind above described—a result which, if chloroform is to be administered at all, is to be regretted, as, while such inhalers do not by any means secure the safety of anæsthesia with this drug, they certainly diminish its dangers.

Usual Mode of Administration.—The plan of administration now generally adopted is to drop the chloroform, about a drachm at a time, upon a piece of lint or a handkerchief or napkin folded into a small open cone, or, as some prefer, into a square. Dr. Reeve uses a cup-shaped piece of sponge fitting over the mouth and nose, the sponge being moistened with water before the chloroform is dropped upon it: by gentle pressure the chloroform is carried to the interstices of the sponge, which thus serve as vaporizing surfaces.

Whatever form of carrier is used, it is desirable that for the first few inhalations the patient should breathe only very dilute vapor, and to this

[1] *Chloroform, its Action and Administration.* [2] *Anæsthetics*, p. 79.

end the carrier should be held three or four inches above his face, in order that full diffusion of the chloroform in the air may be effected before entrance into the respiratory tract: by this care any considerable local irritation may be avoided, and gradually, as the respiratory surfaces become locally anæsthetized, the chloroform-carrier may be brought to within an inch of the patient's face, and thus stronger dilutions be inhaled.

Snow claims that when chloroform is thus given the air breathed by the patient will at the temperature of 70° F. contain 9.5 per cent. of vapor—more than double the proper proportion. Lister, however, who rejects "all complicated apparatus," gives different results: he found that for the first half minute, the air being at 70° F., chloroform was given off from the lower surface of the carrier, or that next the patient's face, at the rate of 24 grs. per minute. Estimating the amount of air inhaled in a minute at 400 cubic inches, and taking Dr. Snow's computation that 20 grs. of chloroform correspond to 15.3 cubic inches of vapor, 4.5 per cent. was ascertained to be the proportion of chloroform to inspired air thus obtained.[1]

These results are, however, purely theoretical. It is self-evident that in practical anæsthesia by this method the percentage of chloroform in the air is a constantly varying one, and may at any moment be too great for safety. Indeed, Lister's only guide as to the strength of the dose administered is the behavior of the patient: if the patient coughs, he regards the vapor as too strong, and withdraws the carrier farther from the face.

Braine's Method.—As indicating a possible factor in the fatal results which have followed the administration of chloroform in certain cases, the following suggestions of Mr. Braine[2] are of value in this connection:

"In looking over the history of the recorded deaths from this anæsthetic, I have been struck by the fact that many of them took place immediately after the addition of a small quantity of the anæsthetic. I think the explanation is that when the facepiece is removed for the purpose of a fresh supply, even though the patient be quite insensible, the stimulation of the fresh air unloaded with vapor causes a deeper breath to be taken, and this being followed by a more complete expiration, the following inspirations are proportionately deeper ones; and on the facepiece being reapplied more chloroform vapor is inhaled than in any previous breath; and not only this, but it is drawn at once into the bases of the lungs. If this be the true explanation, then it clearly points out our line of practice, and shows us that we should never remove the inhaler, but pour chloroform on it while on the patient's face; or, if we do take it away, it must never be replaced within an inch of the face for the first two or three inspirations, thus giving the lungs time to resume their old degree of expansion."

Time and Quantity.—As has already been stated, the physiological effects ordinarily observed in anæsthesia produced by ether and chloroform respectively are precisely analogous, and, as they have already been fully described in this paper, any detailed recapitulation of those effects is unnecessary. The same tests used in ether narcosis may be

[1] Holmes's *System of Surgery*, pp. 528, 529.
[2] *Journal of the British Dental Association*, December, 1884.

applied to determine the full development of the anæsthetic condition from chloroform. Owing to its greater potency, however, a much smaller amount of vapor and a shorter period of time is required to produce anæsthesia with chloroform than with ether.

Surgeon-major J. H. Porter gives the following report of twenty-one cases of chloroform narcosis:[1]

CHLOROFORM.

	Min.	Sec.
Shortest time taken to place under influence	2	30
Longest time " " " "	14	30
Average time " " " "	6	24
Average time under influence	12	48

Smallest quantity used in any one case	1 dr.	
Largest quantity " " "	8 "	
Average quantity " " "	3 "	9 min.

Vomiting occurred in two cases during or after administration of the drug.
Excitement occurred in ten cases during or after administration of the drug.
Great prostration in one case after administration.

SIGNS OF DANGER.—These, as already stated, are to be looked for rather upon the side of the circulation than of the respiration, although not infrequently the respiratory function appears to be primarily involved. Sansom[2] embraces in the following table a synopsis of dangerous symptoms developed in sixty-four cases of chloroform narcosis, and the relative frequency with which they occurred:

"Cessation of pulse	19
(*Concurrent signs*, muscular contraction, vomiting, relaxation of sphincters. In two cases only the pulse showed signs of failure before actually stopping.)	
Pallor of face and lips	11
Cessation of hemorrhage from wound	2
Vomiting, followed by immediate death	2
Muscular excitement	15
(Starting, endeavor to rise up, opisthotonos, epileptiform convulsion, trismus, in many cases accompanied by lividity of countenance.)	
Embarassed respiration	13
(Labored, irregular, or profoundly stertorous.)	
Cessation of pulse and respiration simultaneously	2"

Dr. Anstie[3] states that the number of cases in which, under his own hands, alarming symptoms occurred during chloroform narcosis was twenty-one out of a total number of three thousand and fifty-eight administrations. The leading details of these twenty-one cases he gives in the tables on pp. 123 and 124.

TREATMENT OF DANGEROUS SYMPTOMS.—Artificial respiration, heat, faradization or galvanism, stimulant enemata, atropia—indeed, all the agencies described in connection with the subject of etherization—are equally applicable to the treatment of dangerous complications arising in chloroform narcosis.

Nélaton's Method.—When, however, arrest of the heart's action is the primary and chief source of danger, the remedial measure most urgently demanded would appear to be the inversion or partial inversion of

[1] Erichsen's *Surgery*, p. 61.
[2] *Chloroform, its Action and Administration*, p. 132.
[3] *Stimulants and Narcotics*, pp. 324–326.

	Subject.	Nature of Operation.	Period of Occurrence of Symptoms.	Nature of Symptoms.	Duration of Symptoms.	Mode of Administration.
1	Child, æt. 2 years.	Circumcision.	3 minutes from commencement of inhalation.	Weak, fluttering pulse; gasping respiration; great pallor. Sudden.	15 minutes.	ʒj on a handkerchief.
2	Child, æt. 6 months.	Harelip.	2 or 3 minutes from commencement of inhalation.	Flickering, unrhythmical pulse; gasping breathing; livid lips. Sudden.	10 minutes.	ʒj on a sponge.
3	Man, æt. 40 years.	Hemorrhoids.	End of operation; on a second application after partial recovery.	Sudden arrest of pulse and breathing; livid lips; jaw dropped.	25 minutes.	Snow's inhaler, ʒiij and ʒiss. (Artificial respiration.)
4	Lady, æt. 52 years.	Amputation for cancer of breast.	Middle of the operation; but little blood lost.	Sudden intermittence of pulse; great pallor.	5 minutes.	ʒj on a handkerchief.
5	Lady, æt. 32 years.	Varicose aneurism of lip and cheek.	Less than half a minute from the commencement of inhalation.	Sudden intermittence of pulse; pallor; labored respiration.	10 minutes.	ʒj on a sponge.
6	Man, æt. 60 years.	Hemorrhoids.	Near the end of the operation.	Sudden pallor; flickering, running pulse.	7 or 8 minutes.	ʒiij in Snow's inhaler, then ʒss on lint.
7	Girl, æt. ?	Removal of lower jaw.	3½ minutes after commencement. 1 minute after induction of full anæsthesia.	Sudden flickering of pulse; slow and gasping respiration: great pallor.	5 minutes.	ʒij on lint. (Rapid anæsthesia.)
8	Girl, æt. 19 years.	Plastic operation on face.	After a very few deep inhalations.	Sudden pallor; livid protruded tongue; slow, gasping respiration.	5 or 6 minutes.	ʒij on lint.
9	Man, æt. 38 years.	Radical cure of hernia.	Middle of the operation.	Sudden pallor; very hurried, weak pulse (no large hemorrhage).	A few minutes (very sick for some hours).	ʒij in Snow's inhaler, afterward ʒss on lint.
10	Man, æt. 40 years.	Lithotomy.	2 minutes from the beginning of inhalation.	Irregular, weak pulse; deadly pallor.	12 minutes.	ʒj on lint.
11	Man, æt. 22 years.	Amputation of forearm.	After a few inspirations.	Sudden insensibility; pallor; failure of pulse.	10 minutes.	ʒj on lint.

	Subject.	Nature of Operation.	Period of Occurrence of Symptoms.	Nature of Symptoms.	Duration of Symptoms.	Mode of Administration.
12	Man, æt. 43 years.	Fatty tumor removed from shoulder.	Inhalation continued for 6 minutes.	Extreme dilatation of pupils; stertorous, gasping breathing; pulse pretty regular.	4 minutes.	ʒij in Snow's inhaler.
13	Man, æt. 31 years.	Circumcision.	Middle of operation.	Sudden pallor and failure of pulse, *then* of respiration.	6 minutes.	ʒj on lint; two additional doses of ʒss each.
14	Woman, æt. 29 years.	Removal of scirrhous breast.	After a few inspirations.	Extreme pallor; intermittent pulse.	5 minutes.	ʒj on lint.
15	Girl, æt. 22 years.	Necrosis.	After a few inspirations.	Faintness; hurried respiration.	3 minutes.	ʒj on lint.
16	Boy, æt. 15 years.	Lithotomy.	1 minute from formation of complete anæsthesia.	Sudden pallor and failure of pulse.	5 minutes.	Lint. ʒj first, then ʒss additional.
17	Woman, æt. 32 years.	Plastic operation on perineum.	1½ minutes from commencement of inhalation.	Simultaneous failure of pulse and breathing; jaw fallen.	20 minutes. (Artificial respiration.)	ʒj on lint.
18	Man, æt. 56 years.	Perineal section.	Just after formation of anæsthesia.	Sudden pallor; failure of pulse; livid lips; gasping respiration.	15 minutes.	Lint. ʒj and ʒss additional.
19	Woman, æt. 42 years.	Removal of scirrhous breast.	Sudden and violent epileptiform convulsion at end of 1st minute of inhalation.	Pallor; pulse very weak after fit.	8 minutes.	Weiss's inhaler. (Out of order.)
20	Woman, æt. 37 years.	Removal of breast.	2 minutes from commencement of inhalation.	Sudden pallor; failure of pulse; respiration gasping.	3 or 4 minutes.	ʒj on lint.
21	Man, æt. 21 years.	Evulsion of toe-nail.	Middle of operation.	Sudden pallor; gasping respiration; fluttering pulse.	20 minutes.	ʒij and ʒss on lint. (Artificial respiration.)

the patient. This is a procedure which has long been advocated by the distinguished Nélaton, whose view is that syncope from chloroform is always due to cerebral anæmia, and that, the heart having ceased action, the best method of securing a return of blood to the brain is to place the patient in such a position that it must flow there by gravity. Nélaton's attention was first called to the efficacy of this method by observing that rats, which in the course of experimentation he had apparently killed with chloroform, recovered upon being carried by their tails out of his laboratory. Their resuscitation he attributed to the pendent position in which they were thus placed; and the correctness of his theory has received frequent confirmations in its application to the human subject.

Sims's Case.—An exceedingly interesting account of one of these cases is given in a paper read by the late Dr. J. Marion Sims at the annual meeting of the British Medical Association, held August, 1874, at Norwich. The patient is described as being young and beautiful, and a member of an old and titled French family. As the result of her first accouchement a vesico-vaginal fistula had formed, upon which Dr. Sims was called to operate. His coadjutor was M. Nélaton; Dr. C. J. Campbell, the obstetrician, was selected to administer the chloroform, and there were present besides Drs. Beylard, Johnston, and Mr. Herbert. The operation was performed November 19, 1861, at St. Germain, near Paris. The following forms a part of the account given by Dr. Sims of the syncope and resuscitation of his patient:

"Many years ago I imbibed the conviction of my countrymen against chloroform in general surgery, and have always used ether in preference, never feeling the least dread of danger from it under any circumstances. It is otherwise with chloroform, and in this particular case I felt the greatest anxiety, frequently stopping during the operation to ask Dr. Campbell if all was going on well with the patient. At the end of forty minutes the sutures (twelve or thirteen) were all placed and ready to be secured, and I was secretly congratulating myself that the operation would be finished in a few minutes more, when all at once I discovered a bluish, livid appearance of the vagina, as if the blood was stagnant, and I called Dr. Johnston's attention to it. As this lividity seemed to increase, I felt rather uneasy about it, and I asked Dr. Campbell if all was right with the pulse. He replied, 'All right! go on.' Scarcely were these words uttered when he suddenly cried out, 'Stop! stop!—no pulse, no breathing;' and, looking to M. Nélaton, he said, 'Tête en bas, n'est-ce pas?' Nélaton replied, 'Certainly; there is nothing else to do.' Immediately the body was inverted, the head hanging down, while the heels were raised high in the air by Dr. Johnston, the legs resting one on each of his shoulders; Dr. Campbell supported the thorax. Mr. Herbert was sent to an adjoining room for a spoon, with the handle of which the jaws were held open, and I handed M. Nélaton a tenaculum, which he hooked into the tongue and gave in charge to Mr. Herbert, while to Dr. Beylard was assigned the duty of making efforts at artificial respiration by pressure alternately on the thorax and abdomen. M. Nélaton overlooked and ordered every movement, while I stood aloof and watched the proceedings, with, of course, the most intense anxiety. They held the patient in this inverted position for a long time before there were any manifestations of returning life. Dr. Campbell in his report says

it was fifteen minutes and that it seemed an age. My notes of the case, written a few hours afterward, make it twenty minutes. Be this as it may, the time was so long that I thought it useless to make any further efforts, and said, 'Gentlemen, she is certainly dead, and you might as well let her alone.' But the great and good Nélaton never lost hope, and by his quiet, cool, brave manner he seemed to infuse his spirit into his aids. At last there was a feeble inspiration, and after a long time another, and by and by another, and then the breathing became pretty regular, and Dr. Campbell said, 'The pulse returns, thank God! She will soon be all right again.'

"Dr. Beylard, who always sees the cheerful side of everything in life, was disposed to laugh at the fear I manifested for the safety of our patient. I must confess that never before or since have I felt such a grave responsibility. When the pulse and respiration were re-established M. Nélaton ordered the patient to be laid on the table. This was done gently, but what was our horror when, at the moment the body was placed horizontally, the pulse and breathing instantly ceased! Quick as thought the body was again inverted —the head downward and the feet over Dr. Johnston's shoulders—and the same manœuvres as before were put into execution. Dr. Campbell thinks that it did not take such a long time to re-establish the action of the heart and lungs as in the first instance. It may have lacked a few seconds of the time, but it seemed to me to be quite as long, for the same tedious, painful, protracted, and anxious efforts were made as before; but, thanks to the brave men who had her in charge, feeble signs of returning life eventually made their appearance. Respiration was at first irregular and at long intervals; soon it became more regular, and the pulse could then be counted, but it was very feeble and would intermit. I began again to be hopeful, and even dared to think that at last there was an end of this dreadful suspense, when they laid her horizontally on the table again, saying, 'She is all right this time.' To witness such painful scenes of danger to a young and valuable life, and to experience such agony of anxiety, produced a tension of heart and mind and soul that cannot be imagined. What, then, must have been our dismay, our feeling of despair, when, incredible as it may seem, the moment the body was laid in the horizontal position again the respiration ceased a third time! The pulse was gone and she looked the perfect picture of death. Then I gave up all for lost, for I thought that the blood was so poisoned, so charged with chloroform, that it was no longer able to sustain life. But Nélaton and Campbell and Johnston and Beylard and Herbert by a consentaneous effort quickly inverted the body a third time, thus throwing all the blood possible to the brain, and again they began their efforts at artificial respiration. It seemed to me that she would never breathe again, but at last there was a spasmodic gasp, and after a long while there was another effort at inspiration, and after another long interval there was a third—they were far between; then we watched and waited, and wondered if there would be a fourth; at length it came, and more profoundly, and there was a long yawn, and the respiration became tolerably regular. Soon Dr. Beylard says, 'I feel the pulse again, but it is very weak.' Nélaton after some moments ejaculates, 'The color of the tongue and lips is more natural.' Campbell says, 'The vomiting is favorable; see, she moves her hands, she is pushing against me.' But I was by no means sure that these movements were not merely signs of the last death-struggle, and so I repressed myself. Presently Dr. Johnston said, 'See here, doctor; see how she kicks; she is coming round again;' and very soon they all said, 'She is safe at last.' I replied, 'For Heaven's sake, keep her safe! I beg you not to put her on the table again until she is conscious.' This was the first

and only suggestion I made during all these anxious moments, and it was acted upon; for she was held in the vertical position until she, in a manner, recovered semi-consciousness, opened her eyes, looked wildly around, and asked what was the matter. She was then, and not till then, laid on the table, and all present felt quite as solemn and thankful as I did; and we all in turn grasped Nélaton's hand and thanked him for having saved the life of this lovely woman.

"In a few minutes more the operation was finished, but, of course, without chloroform. The sutures were quickly inserted and separately twisted, and the patient put to bed; and on the eighth day thereafter I had the happiness to remove the sutures in the presence of M. Nélaton and show him the success of the operation."

Notwithstanding its favorable result in this case, inversion is not by any means invariably successful, and many instances are on record in which that as well as all other remedial measures has signally failed to prevent a fatal issue.

Antidotal Power of Amyl Nitrite.—This drug has been found to produce physiological effects which, in at least one important particular, are directly antagonistic to those which result from chloroform narcosis. Under the full influence of the latter drug the arterioles of the brain, at first congested, are ultimately contracted, with resultant brain anæmia, while amyl nitrite produces dilatation of the arterioles through paresis of their walls, and thus diminishes the resistance which the contracted vessels offer to the inflow of the blood. As a consequence of the greater rapidity with which the blood-currents can move in the dilated capillaries the pulsations of the heart are correspondingly accelerated, less resistance being offered to the systolic movement. This, however, is not a true stimulation, because, while there is an increased frequency in the number of heart-beats, the pulse-rate in many instances being more than doubled, their force is decidedly diminished. The wide dilatation of the blood-vessels of the brain, which amounts to one-third of the original diameter, is the important gain secured by this drug; and it can readily be seen how much this condition favors the return of blood to the brain by gravity when inversion is practised, and how the renewed stimulus to the nervous centres of circulation and respiration arising from this return may again call into activity those functions even when they have been completely suspended. It is only indirectly, through this mechanism, that amyl nitrite can be said to act as a cardiac stimulant. Its effect upon the temperature is in large doses one of marked depression, a fall of from one to three degrees being not infrequent, and even lower temperatures have been recorded as the result of its toxic action. Indeed, the dose required to produce the most favorable results in chloroform narcosis is a very small one—five or six drops: if given in too large amounts the flushing of the face and turgescence of the cerebral capillaries, which are its primary effects, will be succeeded by pallor, contraction of the arterioles, and marked depression of the heart's action.

In cases in which animals, previously narcotized by chloroform, have died after large doses of amyl nitrite, it has been found that the heart has become paralyzed, and, together with the entire venous system,

engorged with cyanotic blood. While no fatal cases have yet been reported from its use upon the human subject, and while, indeed, it has been found to be a much safer remedy than was at first supposed, still great caution should be observed in its administration, as many persons are dangerously affected by even minute quantities; while, on the other hand, others can inhale comparatively large amounts without other than the usual physiological effects. As with other remedies of its class, a certain degree of tolerance is established by use, and the drug is now frequently inhaled with considerable freedom by persons who carry it with them constantly to ward off the paroxysm of epilepsy or to deaden the pain of angina pectoris.

As an antidote for chloroform five or six drops are placed upon a napkin or other suitable fabric and held to the mouth and nostrils of the patient. A very convenient method of keeping the drug ready for immediate use is in hermetically-sealed thin glass shells or capsules, containing five drops each. In using, the shells are placed upon the napkin or folded piece of lint and broken by a blow of the hand; the contents, escaping, are then readily inhaled.

So many cases are now on record in which amyl nitrite has been of apparent benefit in cases of suspended animation that no one should fail to have it ready for use when undertaking the administration of chloroform for anæsthetic purposes. When this antidote fails and artificial respiration and faradization prove alike ineffective, tracheotomy should at once be performed for the purpose of insufflation.

Secondary Effects of Chloroform Narcosis.—Abnormal symptoms may occur or pathological changes be developed after anæsthesia produced by chloroform as well as after etherization. The possible secondary effects of the two agents are not essentially different, and their treatment is the same. The necessity for watching the condition of the patient and carefully sustaining his bodily temperature after recovery from anæsthesia need hardly be reiterated here. Owing to the more decidedly depressing effect of the drug, such watchfulness is even more obligatory after chloroform than after ether. When the latter agent has been used secondary bronchial and pulmonary affections are of decidedly more frequent occurrence than when chloroform has been employed. Even with this agent, however, such results are occasionally met with, and when they occur must be treated upon the same general principles as those already detailed in connection with the subject of sulphuric ether. This remark, too, holds good with reference to gastric irritability, hysteria, or other functional disturbances or abnormalities of nervous action.

The most critical case of secondary disturbance the writer has been called upon to treat occurred after narcosis produced chiefly by chloroform, a small amount of ether also having been used. In this case, after the operation (amputation of the arm following a gunshot wound) an almost complete collapse ensued: the respiration was shallow and hurried; the action of the heart weak and tumultuous, no distinct pulsation being perceptible at the wrist; the face was cadaveric, the pupils dilated, and the temperature much reduced, while a profound nausea and incessant retching defeated all attempts to administer nourishment

or stimuli by the stomach. In this condition, with but little amelioration of the symptoms, the patient, a robust young man, remained for nearly twenty hours. During this time heat was constantly applied to the surface of the body and stimulant enemata occasionally administered. The gastric irritability was finally overcome by giving every hour one-fourth of a grain of calomel and one drop of creasote in a pill of breadcrumb, and at shorter intervals a teaspoonful of ice-cream frozen hard and swallowed without previous melting in the mouth, thus combining nutrition with the sedation produced by cold. Under this treatment the patient fully rallied. So complete had been the stasis of blood in the pulmonary tissues that the revival of the vital forces was followed by an attack of acute pneumonia.

The late Dr. Thomas Wood of Cincinnati observed a case[1] in which the very first inhalation of chloroform produced retching, followed by vomiting before the patient became insensible; the anæsthesia was maintained for half an hour, and on the return of consciousness the gastric trouble reappeared, and continued until the close of life on the sixth day.

Occasionally an arrest of the bile-secreting function of the liver follows chloroform narcosis. The most marked instance of this result which ever came under the observation of the writer was in a case in which chloroform had been administered on some three or four successive days to prevent pain in the dilatation of a stricture of the urethra. A very sharp attack of jaundice ensued, the whole cutaneous surface becoming highly colored with the pigmentary matter of the bile.

The Relative Merits of Ether and Chloroform.

Nearly four decades have now elapsed since the introduction of modern anæsthetic processes, and during almost that entire period the relative advantages of ether and chloroform have been the subject of controversy. Such large practical experience in the use of anæsthetics has now been gained, and the knowledge of their physiological effects is so much more extended and accurate than at an earlier period in their history, that reasonably definite conclusions have been reached. That the use of chloroform is attended with greater danger than the use of ether is no longer disputed. All that is now claimed is that with proper care the danger of a fatal issue from chloroform is very small, and that the advantages which it possesses over ether in the more agreeable character of its vapor and the superior speed and efficiency of its action more than counterbalance the slight risk which its use entails. The general tendency of professional sentiment, however, is in antagonism to this view, and in America at least the dangers of chloroform are regarded as too great to justify its use save in exceptional cases. This sentiment is based not only upon the records of relative mortality, which constitute the strongest argument against chloroform, but upon the results of careful physiological research. The sphygmographic tracings[2] on p. 130 show very clearly the difference in the depressing effect upon the pulse of ether and chloroform respectively (Fig. 13).

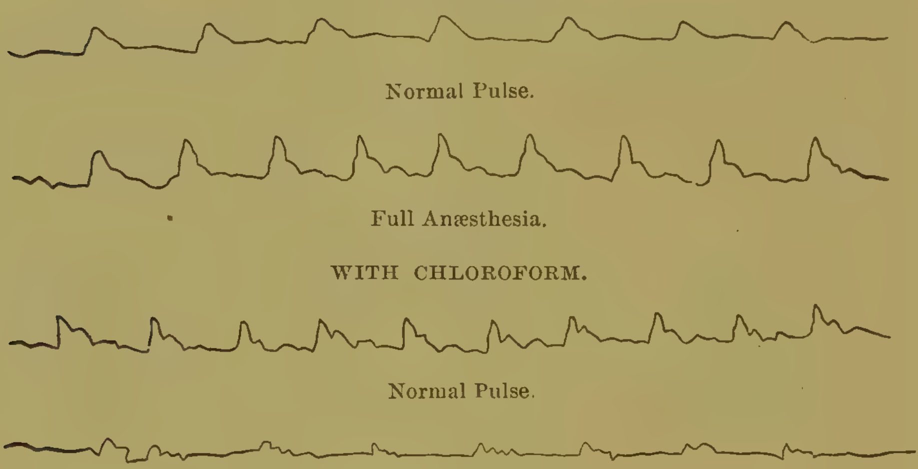
[1] *System of Surgery*, Gross, p. 554.

[2] From Agnew's *Surgery*, p. 290, vol. ii.

The peculiar toxic influence which chloroform exerts upon the heart has been frequently demonstrated, as in the experiments performed by the committee on the action of anæsthetics appointed in 1877 by the British Medical Association,[1] in which they found that the heart of a frog exposed to the vapor of chloroform "became rapidly weaker until it ceased beating;" while when exposed under similar conditions to the vapor of ether "it continued beating for a considerable time—in fact, as long as the experiment continued." Warm-blooded animals also were experimented upon, the trachea being opened and artificial respi-

FIG. 13.

WITH ETHER.



Full Anæsthesia.

ration being carried on by means of a double-acting pump. When chloroform vapor was passed into the lungs with air the committee state that the right ventricle almost immediately began to distend, the heart stopping with the right ventricle engorged with blood. In the case of rabbits the heart often came to a standstill within a minute of the introduction of chloroform into the lungs. "The contrast was most striking when ether was used instead of chloroform, the other steps in the experiment being the same. Ether may be given for an indefinite period without interfering with the heart. We kept up artificial respiration with ether in the circuit for an hour, not including twenty minutes occupied in producing anæsthesia, and at the end of that time the exposed heart was beating as vigorously as at first."

A later report of the same committee[2] states that "chloroform has an unexpected and apparently capricious effect on the heart's action, the pressure being reduced with great rapidity to almost *nil*, while the pulsations are greatly retarded or even stopped. The occurrence of these sudden and unlooked-for effects on the heart's action seems to be a source of serious danger to life—all the more that in two instances they occurred more than a minute after chloroform had ceased to be administered and after the recovery of blood-pressure. . . . .

"As regards comparative danger, the three anæsthetics may be

[1] "Preliminary Report," *British Medical Journal*, Jan. 4, 1879.
[2] *British Medical Journal*, Dec. 18, 1880.

arranged in the following order: chloroform, ethidene, ether; and the ease with which the vital functions can be restored may be conversely stated thus: The circulation is more easily re-established when its cessation is due to ether than to ethidene, and when the result of ethidene than when chloroform has been used. The advantages which chloroform possesses over ether, in being more agreeable to the patient and more rapid in its action, in the complete insensibility produced by it, and the absence of excitement or movements during the operation, are more than counterbalanced by its additional dangers."

A similar committee, appointed by the Boston Society for Medical Improvement, reported in 1861 as follows: "Proper precautions being taken, sulphuric ether will produce entire insensibility in all cases, and no anæsthetic requires so few precautions in its use.

"There is no recorded case of death known to the committee attributed to sulphuric ether which cannot be explained on some other ground equally plausible, or in which, if it were possible to repeat the experiment, insensibility could not have been produced and death avoided. This cannot be said of any other anæsthetic."

Dr. Snow,[1] who gave chloroform freely, said: "I believe that ether is altogether incapable of causing the sudden death by paralysis of the heart which has caused the accidents which have happened during the administration of chloroform. I have not been able to kill an animal in that manner with ether, even when I have made it boil and administered the vapor almost pure. The heart has continued to beat after the natural breathing has ceased, even when the vapor has been administered without air; and in all cases in which animals have been made to breathe air saturated with ether vapor at the ordinary temperatures of this country they have always recovered if they were withdrawn from the vapor before the breathing had ceased; if the animal made a gasping inspiration after its removal from the ether, it recovered."

The distinguished physiologist, Prof. J. C. Dalton, at a meeting of the New York Academy of Medicine, March 18, 1880, said: "The difference between the manner in which death is produced by chloroform and by ether when given to animals has in my experience been very striking—so much so that I long ago abandoned the habitual use of chloroform while experimenting, because it was so annoying to lose an animal just before the experiment was required and could not be postponed."

James Sawyer, M. D., London, says: "The danger of chloroform lies in its lethal power as a cardiac depressant. . . . . Sooner or later chloroform must give way to ether as a surgical anæsthetic, just as ether must drop out of use whenever another anæsthetic as efficient in annihilating pain, but safer to life, shall appear."

Dr. Thomas Jones, who had been for eleven years administrator of anæsthetics in St. George's Hospital, London, wrote in 1872 as follows: "I have administered chloroform in more than six thousand cases. . . . . I confess experience has taught me that chloroform, even when most carefully administered, is more dangerous than is generally supposed.

[1] *Anæsthetics*, 1858, p. 362.

If I was unfortunately compelled to take an anæsthetic, nothing could induce me to take chloroform."[1]

Mr. Jonathan Hutchinson, in a communication to the *British Medical Journal*,[2] says:

"I have been familiar with anæsthetics from the date of their introduction, and have taken great interest in the prevention of mortality from their use. Many years ago, when my duties in connection with the *Medical Times and Gazette* required my daily attendance in the operating theatres of the various hospitals, I was the witness of more deaths from chloroform than have probably fallen under the observation of any one else. Since then I have habitually read all reports of deaths from anæsthetics, and during a long period have also had very large opportunities, both in hospital and in private practice, for judging of the comparative merits of the different ones in use, and also of different modes of administration. The result has been the formation of an opinion so strongly in favor of ether that I should consider myself very culpable if I ever permitted the use of chloroform except in certain cases. The exceptions are the old and the very young: under six months and over sixty years chloroform is, I think, preferable. At all other ages, regardless of states of health, I employ ether. . . . . I have personally lost but one patient (a chloroform case), nearly twenty years ago, but many times have I been alarmed for my patient's safety, and not unfrequently obliged to practise artificial respiration long before signs of returning animation were produced. Now, with ether these cases do not occur. . . . . If only complicated instruments be avoided, and if nothing but the sponge and towel be used, I believe there is absolutely no danger. . . . . It is to the employment of inhalers, which obstruct respiration, I believe, that the occasional ill effects of ether inhalation are due.

"My reason for making the rule as regards age is this: With aged persons ether often disagrees, leaving headache or tendency to stupor for many hours afterward. Chloroform, on the contrary, agrees well with the old, and appears in them to be almost free from risks. The same freedom from danger appears to exist in early infancy."

Prof. J. Morgan, M. D., F. R. C. S., says:[3]

"I have used ether in several cases in which I had used chloroform previously, and found that the struggling and spasmodic stage, which was energetic and almost uncontrollable in chloroformization, was *nil* with ether; . . . . the experience of others confirms this statement. . . . . Sickness of stomach is said to succeed to etherization more than to the use of chloroform: my experience with both leads me altogether to disagree."

The late Prof. Gross, in reply to a letter of inquiry, wrote:

"I have employed anæsthetics ever since their introduction. For many years I employed nothing but chloroform in its pure state, and have never met with a fatal accident, although on several occasions symptoms of a very alarming character arose, and that even when the greatest possible care in its administration was observed. During the last few years I have used ether more frequently than chloroform—first, because it is *unquestionably* a safer agent; second, because I have become more timid in regard to other anæs-

[1] *National Dispensatory*, Stillé and Maisch, p. 407.
[2] Nov. 6, 1880.
[3] *Dublin Journal of Medical Science*, vol. liv., 1872, pp. 360–368.

thetics; and lastly, because professional and public sentiment is decidedly arrayed against chloroform."[1]

These citations might be almost indefinitely extended in evidence of the fact that ether is rapidly supplanting chloroform in the confidence of the medical profession throughout the world. Its use in the hospitals of this country is now almost universal, while, according to a paper read by Dr. Jones before the Cork Med.-Chir. Association, "ether is now used exclusively in at least one-third of the hospitals of Great Britain, and a mixture of ether and chloroform in nearly another third, while there is shown a general disposition of the profession throughout the United Kingdom to abandon the one for the other."[2]

Dr. J. C. Reeve, being desirous of obtaining information as to the relative use of chloroform and ether, and other facts relating to their employment in this country, addressed a circular to the leading surgeons throughout the United States. The following statements, made by Dr. Reeve,[3] are based upon the information thus obtained:

"Some strongly-marked geographical lines can be drawn in this country in regard to the use of the two anæsthetics.

"Thus in all New England, of fourteen surgeons, not one uses anything but ether.

"Taking next the cities of New York, Brooklyn, and Philadelphia, containing together about two and a half millions of inhabitants, and which may be classed together from their proximity and similar metropolitan character, in these cities there are thirty-six surgeons who use ether or chloroform indifferently, and only two who declare that they use only chloroform.

"The remainder of the country may be divided into two sections, North and South, by a line running on the boundary between Maryland and Pennsylvania, along the Ohio River, and thence directly west. These sections present a striking contrast as to the use of anæsthetics. In the North thirty-seven surgeons use ether, twelve use chloroform, and seven either indifferently; four use a mixture of the two; two, the mixture of alcohol one part, chloroform two parts, ether three parts; one, a mixture of one part chloroform to three parts ether; and one, a mixture of one to two.

"In the Southern section of the country twenty surgeons use chloroform and twelve ether. One uses the mixture of one to three, and two use the alcohol-chloroform-ether mixture frequently when ether fails.

"In regard to abandoning the use of chloroform for ether, taking the whole country together, forty surgeons, or about 30 per cent., have made the change within ten years, and nine more within about fifteen years. Five have changed from ether to chloroform, giving as a reason the superior practical advantages of the latter. In the majority of cases the reason given for changing from chloroform to ether is death or dangerous symptoms observed in patients under chloroform. Quite a respectable percentage, however, give only the 'influence of professional opinion' as the determining cause.

"One hundred and forty-four surgeons report that they have seen thirty-four deaths from chloroform and eight from ether, one of the latter having been from obstinate vomiting afterward.

[1] Holmes's *System of Surgery*, p. 550. [2] *Ibid.*, p. 549.
[3] *Ibid.*, "Anæsthetics," p. 550.

"Dangerous symptoms from chloroform are reported as having been witnessed two hundred and thirty-one times. . . . . Dangerous symptoms from ether are reported as witnessed fifty-six times."

Prof. Lyman in his work on *Artificial Anæsthesia and Anæsthetics* (pp. 136–196) gives the details of three hundred and twenty-five cases of sudden death from chloroform, and says: "A perusal of the history of these cases is sufficient to produce the conviction that comparatively few of the cases of death from chloroform have been acknowledged and published. The vast majority of the cases thus far reported have occurred in the hospitals of Great Britain. A death from the use of chloroform in private practice is seldom announced, unless it may chance to have happened in the office of an unlucky dentist. Then, of course, there is great publicity and the event is carefully chronicled. Occasionally some elderly physician alludes in a cautious manner to a case of which he was cognizant long years ago in a remote quarter of the earth. In some such way it has been published[1] that in Cincinnati and its adjacent territory not less than twenty-five deaths from chloroform had occurred since the introduction of that anæsthetic."

Prof. Bartholow[2] states that the reported deaths from chloroform now (1879) amount in the aggregate to about five hundred.

Dr. Laurence Turnbull[3] gives three hundred and seventy as the total of reported and fully authenticated cases of death from chloroform which he had been able to obtain up to the year 1879.

Chloroform in Obstetrical Practice and for Young Children.—Many of those who deprecate the use of chloroform for other classes of cases claim that young children and women in the throes of labor possess a special immunity from danger in chloroform narcosis. So far as children are concerned, the only reasonable explanation of such immunity is that suggested by Dr. Reeve,[4] that chloroform is more carefully administered than when it is employed upon adults. Evidence that while intrinsically unsafe for adults it is intrinsically safe for young children is not forthcoming, and can hardly be assumed as a postulate to any known principle of physiological law. It is certain that children succumb far more readily to the toxic influences of all other narcotics than do adults, and it is difficult to believe that the rule should not hold good with chloroform. Indeed, that children have died under chloroform is a matter of record.[5]

The testimony as to the almost absolute safety with which it can be given to parturient women is very strong. According to the committee of the Royal Medical and Chirurgical Society there is no well-authenticated instance of sudden death recorded, either in this country or abroad, as occurring from the administration of anæsthetics during natural labor when such administration has been conducted by a qualified medical man.

Prof. Bartholow[6] says that "chloroform is to be preferred in labor, because more pleasant to inhale, more prompt in action, and without inflammability. The consideration of safety must necessarily take

[1] *The Clinic*, p. 150, March 31, 1877. [2] *Materia Medica and Therapeutics*, p. 367.
[3] *Anæsthetic Manual*, p. 113. [4] *American Journ. Med. Sciences*, Jan., 1867, p. 182.
[5] *Anæsthesia, loc. cit.*, p. 166. [6] *Materia Medica and Therapeutics*, p. 367.

precedence, but experience has shown that chloroform is perfectly safe in labor when properly administered."

Various theories have been presented in explanation of the greater safety of chloroform in this class of cases. By some it is claimed that the extreme pain incident to labor increases the resistance which the vital forces offer to the toxic influences of the drug. This increased resistance, however, is not apparent in the earlier stages of anæsthesia, women in labor yielding quite as readily to the anæsthetic as those who are non-parturient, and, as pain is thus found not to retard the primary influence of the agent, there is no good reason for the assumption that it would modify favorably its extreme toxic effects. Indeed, such a theory is in direct antagonism to the universally-recognized fact, so frequently illustrated in obstetrical practice, that extreme pain powerfully depresses all the vital energies, and when too prolonged causes death from exhaustion.

A more plausible theory is that the "physiological congestion of the brain produced by straining in labor antagonizes the cerebral anæmia which is the physiological effect of chloroform." Prof. Lyman considers this questionable, and says: [1]

"The greater immunity of these patients is probably due to the fact that they are selected patients, as it were. Young women in the prime of life, at an epoch when all the nutritive functions of the body are at their highest degree of activity, must necessarily present the best possible cases for tolerance of anæsthesia. Such patients are in a very different condition from that in which we find the victim of disease or of shock upon whom the surgeon is called to operate."

This theory would seem to find confirmation in the similar exemption from danger which has attended the use of chloroform in military surgery. Soldiers, to a far higher extent than parturient women, are a selected class, usually in the prime of life, and the recorded cases of death from chloroform among them are very few in number. Dr. Hunter McGuire of Richmond, Va., states that in the division of the Confederate Army to which he was attached it was administered twenty-eight thousand times without a death;" [2] and reports almost equally favorable have been given concerning its use in the more recent wars of continental Europe.

It does not fall within the scope of this paper to discuss the details of anæsthetic practice in those departments of medicine foreign to dentistry. The question as to the value of anæsthetics in obstetrics and gynæcology, or as to the normal or pathological conditions which render their employment permissible or imperative, will not be considered. The writer, however, fully agrees with the conclusion of Prof. Lyman,[3] that the true use of chloroform in obstetrical practice is as an anodyne, and that "when complete anæsthesia is required for the graver operations of midwifery, sulphuric ether should be preferred to all other articles."

CHLOROFORM IN DENTISTRY.—Whatever the other fields of medicine in which chloroform may safely be employed, there are now but few who

[1] *Artificial Anæsthesia and Anæsthetics*, p. 72. [2] Holmes's *System of Surgery*, p. 551.
[3] *Op. cit.*, p. 69.

dissent from the opinion that its special dangers absolutely inhibit its use in dentistry: the large mortality which has attended its employment in operations upon the teeth sufficiently attest the justice of this conclusion. In the three hundred and twenty-five cases of death from chloroform collected by Prof. Lyman there were thirty-five which occurred during or after its administration for the extraction of the teeth, this being more than for any single operation except the "removal of tumors, including cancerous breasts and tongues," during which operations also thirty-five deaths took place. Dr. Turnbull reports during the decades from 1869 to 1879 twelve cases of death from chloroform given for extraction of the teeth, one from chloroform given for toothache, one where given for asthma and toothache, and one in which the operation was for epithelioma of the tongue. This list, large as it is, would doubtless have been vastly augmented had not the widespread introduction of nitrous oxide gas as an anæsthetic, which took place during and immediately preceding that period, generally displaced from use in dentistry the more dangerous anæsthetics. Even now, however, cases are occasionally reported.

Deaths from Chloroform in Dental Practice.—Thus, quite recently Mrs. Dr. E. M. Watts, the wife of a physician of Portsmouth, Va., fell a victim to the drug, although her own husband was the administrator. According to the report in a local paper, she had taken the drug on three previous occasions without any bad effect, but always against the earnest remonstrances of her husband. She was in a reclining chair. The quantity inhaled was about two drachms on an open sponge. Teeth extracted ten, and three roots. Time from commencement of inhalation to end of extracting teeth, not over five minutes. Chloroform administered by Dr. Watt, teeth extracted by Dr. John Linn.

Still more recently (Feb. 7, 1884) a very similar case is reported in the Scranton (Pa.) *Republican*, the victim being Mrs. James Stevenson, a lady thirty-six years old and the mother of seven children. She was accompanied to the dental office of Dr. W. H. Heist by her physician, Dr. A. Strang, who "examined her very carefully as to the condition of her heart and lungs, and found her a proper subject for the administration of the soporific." Sixteen teeth were to be removed because of a neuralgic affection attributed to their decayed condition and from a desire for an artificial denture. Ether and chloroform were given (proportions not stated) by Dr. Strang, and the teeth extracted by Dr. Heist. The report gives the result as follows:

"The physician noted the condition of the pulsation and respiration carefully during the operation. In two minutes after the first inhalation two teeth were taken out, and the lady revived, rose to a sitting posture, spit out the blood, and lay back again. More of the chloroform and ether was given, and then nine teeth were removed, after which she again revived, spit, rested, and asked if the teeth were not all out. The anæsthetic was again applied, and five more teeth were taken out, completing the work of extracting. About two minutes after the last tooth was taken out she threw her head violently back, rolled up her eyes, and apparently fainted away. All the remedies usual in cases of swooning were resorted to. Cold water was dashed in her face, artificial respiration was performed, then hypodermic

injections of brandy were made, without any response whatever in the way of revival. Another physician was called in, and arrived in ten minutes after she had fainted. Her pulse was then beating faintly, but no effort could restore her to animation.

"The post-mortem," says the report, "revealed the lungs in a condition of collapse and somewhat congested, proving that breathing stopped before the heart ceased to pulsate. The right side of the heart was dilated and had thin, weak walls. There was no valvular disease of the heart. On the top of the heart was found a small cystic tumor that seemed to press upon the artery—the coronal artery—that supplies the heart with nourishment. This tumor, by pressing upon an important nerve, might have been a considerable factor in causing her death. The stomach showed a catarrhal condition and gastritis was indicated."

The details given concerning the first of these cases are too meagre to afford a basis for judgment as to the influence which the mode in which the anæsthetic was administered may have exerted in producing the fatal result. Without presuming, as details are not given, to sit in judgment upon the operative procedure in either of these specific cases, the writer would remark that, as a general principle, the conditions which render necessary the sacrifice of so large a number of teeth at any one time in the history of a human life ought to be, in the present state of dental science, exceptional: malignant disease of the jaws or alveoli sometimes demands such a sacrifice, and there are incurable pathological conditions of the teeth themselves which sometimes, though rarely, make the extraction of a considerable number imperative; but it has never occurred in the experience of the writer that the ravages of simple caries or the existence of lesions directly or indirectly dependent upon caries have wrought such havoc in a human denture that something far better for the patient, even if neuralgic, could not be accomplished than the extraction of one-half the normal dental equipment. In a vast majority of cases of true neuralgia such wholesale edentation is utterly futile, the last state of the patient being worse than the first.

Assuming that the extraction of so large a number of teeth at a sitting becomes necessary, chloroform is, certainly, not the agent which should be employed as the anæsthetic.

Reasons for Fatality in Dental Practice.—The fact has already been emphasized in connection with the subject of sulphuric ether (see pp. 84–87) that, owing to the close contiguity of, if not direct commissural connection between, the nucleus of the fifth nerve and the nucleus of the pneumogastric, as well as to their intimate reflex relations, the region supplied by the fifth is one of special danger when operated upon under the influence of anæsthetics. If the patient be imperfectly anæsthetized, the shock produced by the extraction of a single tooth may so stimulate the inhibitory function of the pneumogastric as to produce complete arrest of the cardiac movements: how much more likely is this be the result when many teeth are extracted, and when the heart itself is weakened by the specifically depressant influence of chloroform! Beyond all question it is to this combination of influences that the great mortality from chloroform narcosis in dentistry is directly due. It is very evident that in the second of the cases just quoted anæsthesia

was at no time sufficiently profound. Even with chloroform, much less with chloroform and ether, anæsthesia cannot, in an adult, be safely effected in two minutes, which was the time allowed before the extraction of the first two teeth: the quick revival, sitting up, spitting out of blood, and lying back again, repeated after each series of extractions, all indicate that anodyne and not full anæsthetic doses were administered.

The coroner's jury found that the deceased came to her death "from a fainting fit caused by excitement and shock incident to the extraction of a number of teeth, and that there was sufficient disease of the heart—though not readily recognizable during life—to cause death by any unusual excitement;" but had a profound anæsthesia been effected by such an agent as sulphuric ether, used alone, the heart would not have been specifically assailed, shock would not have been received or transmitted, excitement would have been calmed. That the influence of the anæsthetic is a potent factor in the mechanism of death under such conditions is fully demonstrated by the relatively small mortality which has attended similar dental operations under ether, and by an almost absolute immunity from a fatal result which has followed even the most wholesale extractions under nitrous oxide gas. Clearly, in dental practice shock or excitement, alone or combined, very rarely kills, for both conditions are as likely to be incident to operations under nitrous oxide gas as under other agents: it is the drug which kills.

That chloroform, as well as other anæsthetics, is often ignorantly given by incompetent persons, and that many cases of fatality are attributable to this cause rather than to inherent vices in the agent itself, is unquestionable. Case after case might be quoted in which every condition necessary to the safe induction of the anæsthetic state with either ether or chloroform has been systematically violated; and in a great measure the responsibility for such a state of things must rest upon the lax public sentiment which until quite a recent period has made it possible for even the most ignorant and incompetent to practise either medicine or dentistry in any State in the Union. No small share of the blame, however, must attach to the schools of instruction. The subject of anæsthesia and anæsthetics has too often been treated as a matter of trivial importance, to be dismissed in a single lecture or less. Even now there are not many medical or dental colleges in which full and detailed instruction in the physiological and pathological relations of artificial anæsthesia is given, and practical drill enforced both in the details of the administration of anæsthetic agents and the institution of resuscitative measures when such are required.

Ethyl Bromide.

This substance (C_2H_5Br), otherwise known as bromide of ethyl or hydrobromic ether, has been used to so considerable an extent in dental practice, and by some practitioners is still so highly recommended, that a brief account of its properties and effects would seem to be demanded.

Discovery and Early Use.—It was discovered in the year 1827 by Serulas. In 1849, Dr. Thomas Nunnelly of Leeds used it in experi-

ments upon animals, anæsthetic effects being produced in several instances. Owing to the costliness of the drug these researches were abandoned for the time. Dr. Nunnelly subsequently employed it as an anæsthetic upon the human subject, and in a paper read before the British Medical Association in 1865 stated that he had given it as an anæsthetic "in all the principal operations at the Leeds General Eye and Ear Infirmary." Dr. Richardson of London, too, strongly recommended it. Rabuteau of Paris in the year 1876 experimented with it both upon animals and plants: the latter he found to die in two hours after exposure to an atmosphere saturated with the vapor of the drug. In 1878, Dr. Laurence Turnbull of Philadelphia gave it repeatedly for the relief of tinnitus aurium and other affections of the ears, and also as an anæsthetic in minor surgical operations, he being the first to use the agent in this country. Dr. R. J. Levis soon introduced it into his surgical practice, and in April, 1879, it was used by him in the Pennsylvania Hospital. Since that period it has been used for anæsthetic purposes in hundreds of cases, both in this country and in Europe.

Preparation and Properties.—Ethyl bromide is prepared by distilling together absolute alcohol and bromine in the presence of amorphous phosphorus. The following equation represents the reaction:

$$\underset{\text{Bromine.}}{5Br_2} + \underset{\text{Phosphorus.}}{P_2} + \underset{\text{Alcohol.}}{10C_2H_6O} = \underset{\text{Ethyl bromide.}}{10C_2H_5Br} + \underset{\text{Phosphoric acid.}}{2H_3PO_4} + \underset{\text{Water.}}{2H_2O}.$$

It is a colorless, transparent liquid, having a characteristic ethereal odor and a warm, sweetish taste, disagreeable in character. In water it is but slightly soluble, but alcohol and ether combine with it in all proportions. The density of the fluid at 59° F. is 1.419; vapor density, 3.754; boiling-point, 105.2° F. When ignited, which is not readily accomplished, it burns with a greenish flame free from smoke.

Great difficulty is found in obtaining ethyl bromide in an absolutely pure state, and the utmost care in its preparation is required. Owing to the instability of the compound, secondary decompositions may occur either during or after its distillation, the impurities thus formed being often highly deleterious.

Effects of Ethyl Bromide.—As it seems quite certain that this agent will never come into general use, a full analysis of its physiological effects is not deemed necessary in this place. They differ only in minor particulars from those already detailed in connection with the study of ether and chloroform. Like the latter agent, it has been found to greatly depress the circulation, diminishing both the force and frequency of the movements of the heart. According to Dr. Ott, it kills by paralysis of the respiratory centres, to which paralysis the cardiac depression is tributary.

The advantages claimed for the agent are that it is much more rapid in its action than chloroform, and produces less muscular excitement; that the vapor when inhaled in the proportions of from 8 to 10 per cent. produces little bronchial irritation, and that vomiting is of infrequent occurrence; while a rapid elimination from the system through

the lungs and kidneys ensures a speedy and full recovery. Dr. Roberts[1] says: "The effect is transient: in a few seconds after removing the towel the patient is able to talk intelligently, and in a minute or two he can leave the operating-table and walk away with scarcely a stagger. This circumstance is doubtless an element of safety, but is undesirable at times, because when necessary to remove the towel the patient almost instantly recovers sensibility. . . . . The amount consumed varies, of course, with the time the anæsthesia is maintained; usually one or two fluidrachms are poured upon the towel and repeated as demanded."

Fatal Cases.—Notwithstanding the claims in its favor, several deaths have occurred from its use, and but few now continue its advocacy. One death occurred May 26, 1880, in Jefferson Hospital, Philadelphia, the patient being a young man much debilitated by disease of the kidneys and stone in the bladder, the operation being for the removal of the calculus. Before the administration of the anæsthetic fifteen grains of quinine and "a stimulant" were given. About three fluidrachms of the anæsthetic were required to produce full anæsthesia, but immediately after the commencement of the operation respiration suddenly ceased, and all efforts at resuscitation—artificial respiration, amyl nitrite, the electric current, etc.—proved abortive. As the autopsy showed, the case was complicated not only by disease of the urinary tract, but also by serious lesions in the lung-tissue.

Another case occurred in the practice of Dr. J. Marion Sims. The details are given in a paper read by him before the New York Academy of Medicine March 18, 1880. The operation required was the removal of an enlarged ovary. At the end of ten minutes after beginning the inhalation of the anæsthetic the patient, a Miss B——, "could be kept quiet. Pulse 86, full and strong; respiration soft and regular, but above regular standard. During first twenty minutes had used two ounces of the hydrobromic ether. At that time she vomited the contents of the stomach. At the end of forty minutes she vomited again with some straining." The operation lasted one and a half hours. Her condition was good during the whole time. No unusual dilatation of the pupils. In all, about four and a half or five ounces of ethyl bromide were used. She recovered quickly from the anæsthetic after being put to bed, but had "the most distressing vomiting imaginable." This continued uninterruptedly, accompanied by free movements of the bowels —thin, yellowish, watery, very offensive, having so strong a smell of ethyl bromide as to attract the attention of the inmates of the house: five movements occurred in three hours. The pulse and respiration became very rapid, and the pulse finally imperceptible. The patient died in twenty-one hours after the operation. Severe convulsions occurred just before death, with "frantic ravings and heartrending screams."

At the post-mortem all parts of the body seemed saturated with ethyl bromide. When the kidneys were laid open and brought near the nose, "it was almost like smelling ether from an open bottle." The kidneys were healthy, but only five ounces and one drachm of

[1] Bryant's *Surgery*, p. 959.

urine were passed after the operation, and catheterization a few hours before death produced no urine. There was no peritonitis.

In commenting upon the case Dr. Sims remarks:

"In this case the kidneys were locked up, as it were, and hence the bowels were called on to aid the lungs in getting rid of the poison. It is altogether probable that the cholerine was due wholly to the action of ethyl bromide. If the operation had been comparatively short, if it had lasted only twenty or thirty minutes, if it had terminated before my patient's system, solids as well as fluids, became thoroughly saturated with it,—she would in all probability have recovered; but as it was it seemed to kill by supersaturation which could not be eliminated, even with the aid of the whole mucous tract of the alimentary canal to aid the lungs. . . . . The inference I draw from the facts in the history of the case is that the anæsthetic was the cause of death, while the manner of death may have been by uræmic poisoning. The lesson from this is never to give bromide of ethyl in prolonged operations, and never to give it where there is organic disease of the kidneys."

Nature of Toxic Influence.—Much of the favor with which the suggestion of the use of ethyl bromide was received was based upon a vague and mistaken assumption that because the less volatile but more permanent combinations of bromine, as in potassium bromide, etc., could be taken internally in large doses with only mildly sedative effects, therefore when it simply took the place of oxygen in the ethyl radical it must prove equally innocuous. Of course nothing could be more mistaken than this line of reasoning, because bromine uncombined is a highly irritant poison, and its connection with the ethyl molecule is so unstable that, as already indicated, its decomposition is most easily effected, and possibly is effected in the circulation, whereas the bromides of potassium, sodium, etc. are stable salts, which enter the system and are eliminated from the system as such, the toxic influence—both physiological and chemical, if there be a distinction—of the bromine being to a great extent masked by its molecular union with the bases with which it has entered into combination.

But without assuming that such a decomposition usually occurs, it is now a well-established principle that the presence of any toxic substance in an anæsthetic, however firmly it may be held in combination by its atomic affinities, is a source of danger. In other words, those anæsthetics are safest whose elements in themselves are harmless. Thus, taking the structure of sulphuric ether, $2(C_2H_5)O$, we have in carbon an agent which is altogether inert except in combination, and in hydrogen and oxygen two gases, either of which, under proper conditions, may be breathed with entire impunity, and one of which is necessary to life. The nitrogen, which is the element in combination with oxygen in nitrous oxide gas, N_2O, is also, when uncombined, an inert substance, which when breathed acts only as a diluent of the oxygen of the air. Thus, these two agents, being built of elements so little inimical to man's safety, are demonstrated to best conserve that safety in practical anæsthesia.

It is true that carbon, hydrogen, oxygen, and nitrogen, although singly thus harmless, are capable of entering into combinations, as in

the poisonous alkaloids, possessing the most deadly potencies; and such potencies, indeed, if not restrained, they possess in the ether and nitrous-oxide combinations; but the practical result still remains that under proper restraint they have proved less harmful than all other agents of their class, and that the combination of an atom of bromine instead of an atom of oxygen with the ethyl radical increases the dangers of anæsthesia.

This is also true of all chlorine combinations with either methyl or ethyl radicles, such as chloroform, $CHCl_3$, or ethidene, $C_2H_4Cl_2$. The latter agent the anæsthetic committee of the British Medical Association found to be safer than chloroform, but less safe than ether. Its superiority over the former agent is easily explained by the fact that it contains so much less chlorine proportionately to the other elements which enter into its composition, while the superiority of ether is equally attributable to the entire absence of chlorine and all other toxic elements from its molecule.

Methyl Iodide.—This view of the active part which bromine and chlorine play in the toxic effects produced by those anæsthetics into which they respectively enter finds further confirmation in the poisonous effects produced by methyl iodide, CH_3I, which, being volatile, has also been experimented with for anæsthetic purposes. As bromine, chlorine, and iodine are nearly identical in their leading chemical affinities, so are they closely allied in their physiological effects. Methyl iodide, like ethyl bromide, is easily decomposed, either in the respiratory tract or in the circulation, the specific influences of the drug being manifested by the usual irritant effects upon the broncho-pulmonary mucous membrane, resulting in cough, increased mucous secretion, and frequently in spasm of the glottis. Concerning this agent Sir James Y. Simpson[1] says: "I found it very powerfully anæsthetic, but dangerously so. After inhaling a very small quantity for two or three minutes I remained for some seconds without feeling much effect, but objects immediately began to multiply before my eyes, and I fell down in a state of insensibility, which continued for upward of an hour. I did not completely recover from the effects of it for some days."

The greater violence of the chlorine, bromine, and iodine derivatives is by Professor Leffmann thought to be due in part to the difficulty of oxidation of these elements; ether, alcohol, and bodies of that class being with some ease converted into carbon dioxide and water, while the halogens are not so convertible. Be the cause what it may, enough has been said to show conclusively that the volatile compounds of chlorine, bromine, and iodine are, when inhaled, alike dangerous, although not equally so. It seems probable that the chlorine compounds are the least harmful of the three; but whatever may be the contingencies making necessary their employment in other departments of the healing art, they certainly have no place in the practice of dental surgery.

ANÆSTHETIC COMBINATIONS.—Admitting that the volatile chlorine, bromine, and iodine compounds are specifically poisonous, the objections to their use as anæsthetics are not materially modified by giving them

[1] *Anæsthesia*, p. 262.

in combination with less dangerous agents, such as sulphuric ether and alcohol. Numerous formulæ for these combinations have been given to the world backed by the highest commendations of their inventors; but while, on general principles, it may be assumed that the less of a dangerous anæsthetic inhaled the better, and therefore that the substitution of ether for chloroform in any proportion is an advantage, still the effects of chloroform are so erratic, and the quantity required to produce fatal results has sometimes been so small, that, practically, the dangers of anæsthesia are hardly diminished by such combinations. It is not found that the specific influence of chloroform is materially modified because ether is being inhaled at the same time; indeed, it would be modified only in degree even if there were a chemical union, instead of an imperfect mechanical admixture, of the two vapors; for it must be remembered that each fluid has its own point and rate of vaporization, and that they therefore do not by any means pass into the respiratory tract in the same proportions as those in which they were commingled in the liquid form. This was long ago shown by Dr. Snow, who said: "Some practitioners have recommended the inhalation of the vapor from a mixture of chloroform and ether, but the result is a combination of the undesirable qualities of both agents, without any compensating advantage. Ether is about six times as volatile as chloroform; that is to say, if equal measures of each be placed in two evaporating dishes kept side by side at the same temperature, the ether evaporates in about one-sixth the time of the chloroform; and when the two liquids are mixed, although they then evaporate together, the ether is converted into vapor much more rapidly; and in whatever proportions they are combined, before the whole is evaporated the last portion of the liquid is nearly all chloroform: the consequence is that at the commencement of the inhalation the vapor inspired is chiefly ether, and toward the end nearly all chloroform, the patient experiencing the stronger pungency of the ether when it is most objectionable, and inhaling the more powerful vapor at the conclusion, when there is most need to proceed cautiously."[1]

Combinations with Alcohol.—Owing to the stimulating effect of its vapor a combination of alcohol with chloroform or with chloroform and ether is much favored by many operators. The following formula, known as the "A. C. E. mixture," was among others recommended by the chloroform committee of the London Medico-Chirurgical Society:

Alcohol,	1 part;
Chloroform,	2 parts;
Ether,	3 parts.

Dr. Sansom states that he has found the alcohol vapor to sustain the action of the heart during the influence of chloroform, and recommends a combination of equal parts of chloroform and absolute alcohol as "an excellent anæsthetic, which gives off a proportion of chloroform vapor in a given time exactly half of that which is given off by chloroform pure and simple."

As shown by Snow, and as has since then been repeatedly demonstrated, all these mixtures are merely mechanical, and their constituents

[1] *Anæsthetics*, pp. 369, 370.

evaporate in the order of their volatility—ether first, chloroform next, and alcohol, if present, last of all, so that at no stage in the administration of such mixtures can the operator be sure of the exact nature of the vapor inhaled.

Nitrous Oxide.

Nitrous oxide (N_2O) is a colorless gas having a faint odor and sweetish taste. Its specific gravity, compared to air, is about 1.6. By a pressure of fifty atmospheres at a temperature of 40° F. it may be condensed into a liquid form, and in this state, when confined in vessels of sufficient strength and impermeability, may be kept for an indefinite period. Although volatilizing with great rapidity when released from pressure, the liquefied gas may, with proper precautions, be drawn into test-tubes or other receptacles for examination. It is a colorless fluid, having a specific gravity of 0.908. At a very low temperature (— 148° F.) it congeals into a transparent crystalline solid. When liquid nitrous oxide and carbon disulphide are mixed and evaporated *in vacuo* a temperature of — 220° F. may be obtained. So rapid is the volatilization of the liquefied gas that when mixed with water and allowed to volatilize in air the water will be frozen.

At high temperatures nitrous oxide supports combustion almost as effectively as pure oxygen, and all combustibles, when once ignited, continue to burn in it with great brilliancy. Thus the incandescent wick of a newly-extinguished taper, if placed in a receiver containing the gas, will be kindled into flame, as also will slowly-burning charcoal, sulphur, or phosphorus. This effect, however, is due to the decomposition of the nitrous oxide molecule effected by contact with the ignited object: oxygen, being thus set free from its chemical union with nitrogen, is in a condition to satisfy its chemical affinities by entering into new combinations with the elements of the combustible, just as when it is presented merely mechanically mixed with nitrogen in atmospheric air.

Nitrous oxide is to a limited extent soluble in water. At ordinary temperatures water absorbs about 80 per cent. by volume of it (Dalton). The warmer the water the less gas is dissolved or retained in solution. According to Bunsen,[1] one volume of water at a temperature of 0° C. (32° F.) and 0^m .76 barometric pressure dissolves 1.3052 volumes of the gas; at 8° C. (46.4° F.), 0.9858 of a volume; and at 23° C. (73.4° F.), only 0.6216 of a volume.

Preparation.—Nitrous oxide is usually obtained by the decomposition of ammonium nitrate (NH_4NO_3), which when heated to a temperature of about 392° F. yields water and nitrous oxide gas ($NH_4NO_3 = 2H_2O + N_2O$). The ammonium nitrate itself is prepared by acting upon ammonia or its carbonate with nitric acid diluted with an equal volume of water. After all chemical action has ceased the solution is evaporated to the point of solidification. A crystalline mass remains which is broken up into fragments of convenient size and sent into commerce. The salt crystallizes in rhombic prisms. By processes known to the manufacturers it may be obtained in a granulated condi-

[1] *Gasometry.*

tion; which form is, owing to the relatively small size of the granules, convenient for introduction into the retort.

The crystals obtained by the simple cooling of a hot saturated solution of the salt contain a large amount of water of crystallization $NH_4NO_3 12H_2O$ (Attfield), but by exposing the crystals to the temperature of 310° F. the water is driven off and the anhydrous salt (NH_4NO_3) remains. This, however, has some affinity for water, and deliquesces upon the surface when exposed to moist air: half its weight of water will dissolve it completely. In dissolving a very considerable reduction of temperature takes place. As upon the absolute purity of the ammonium nitrate depends the purity of the gas prepared from it, the salt should be carefully tested before using.

Tests for Purity of Ammonium Nitrate.

General Test.—A pure specimen slowly heated in a test-tube or upon platinum-foil will be completely volatilized, leaving no residue.

Test for Acids or Alkalies.—A strong solution of pure ammonium nitrate in distilled water should not give either an acid or alkaline reaction, but should be neutral. Hence the color of either red or blue litmus-paper dipped in such a solution should remain unchanged.

Test for Chlorides.—Any chlorides present may be detected by placing in an aqueous solution of the ammonium nitrate a few drops of nitric acid—to prevent carbonates, phosphates, or free ammonia, should such substances also contaminate the specimen, from interfering with the test—and then adding a solution of silver nitrate: silver chloride will appear as a white precipitate.

Test for Sulphates.—The presence of sulphates may be determined by adding to the solution of ammonium nitrate, acidulated with nitric acid as in the test given for chlorides, barium chloride, which, with a sulphate, will form a white precipitate of barium sulphate.

These tests are not by any means superfluous, even when the salt has been obtained from known and reliable sources, as, assuming that it has been properly made, there is always the possibility of subsequent contamination through the absorption of deleterious vapors, such absorption being favored by its deliquescent properties. An instance of this kind occurred some years ago in the laboratory of a leading manufacturing chemist in this city, where by accidental exposure to chlorine fumes a considerable quantity of that gas was absorbed by the ammonium nitrate in stock, attention being first called to the fact by the unpleasant effects produced upon patients by the nitrous oxide prepared from it. Had the silver test been used the presence of the chlorine would have been revealed.

There is greater need for care in the examination of the ammonium nitrate when it has been prepared by the reaction between ammonium sulphate and potassium nitrate—a process which for commercial reasons is sometimes resorted to by manufacturers. The reaction is as follows:

$$\underset{\text{Ammonium sulphate.}}{(NH_4)_2SO_4} + \underset{\text{Potassium nitrate.}}{2KNO_3} = \underset{\text{Ammonium nitrate.}}{2NH_4NO_3} + \underset{\text{Potassium sulphate.}}{K_2SO_4}.$$

The resultant products, which are in solution, are separated by a method dependent entirely upon their different rates of crystallization. Unless this process is conducted with the most absolute care, there is always the possibility that the ammonium nitrate thus prepared may be contaminated either with potassium nitrate or potassium or ammonium sulphate; with the further possibility that, as the latter salt is prepared by neutralizing with sulphuric acid the ammoniacal liquor obtained in the manufacture of illuminating gas, it may be found to contain various pyroligneous impurities deleterious in character.

APPARATUS FOR MAKING AND STORING NITROUS OXIDE.—A good form of apparatus for the preparation of nitrous oxide is shown in Fig. 14, p. 147. It consists of a stand and chain for suspending the retort, a heating apparatus, three wash-bottles, and a gasometer.

The retort figured is really the old alembic with an invagination in the upper part, or "head," intended to condense the steam arising during distillation and receive the moisture formed by such condensation, thus in an imperfect manner fulfilling the purposes of the worm condenser. At the high temperature required to decompose ammonium nitrate the head of the alembic becomes too much heated to serve as a condenser, except in a very imperfect degree. The larger surface which the invagination presents to the air aids to a limited extent in keeping the head, as well as the beak connecting it with the wash-bottles, cooler than the lower part, or body, of the alembic, and thus overheating of the rubber tubing used in making the connection is somewhat controlled. In the usual form of glass retort the same object is effected by the greater relative length of its beak. The alembic, however, will be found less cumbersome in use and less liable to fracture. Its head contains a tubular orifice for the introduction of the ammonium nitrate, this being closed by a cone-shaped rubber stopper.

The height of the alembic is $11\frac{1}{2}$ inches, its capacity 5 pints. The height of the stand to which it is suspended is $33\frac{1}{3}$ inches. To the stand is attached a bracket upon which the heating apparatus may be placed and lifted or lowered at pleasure.

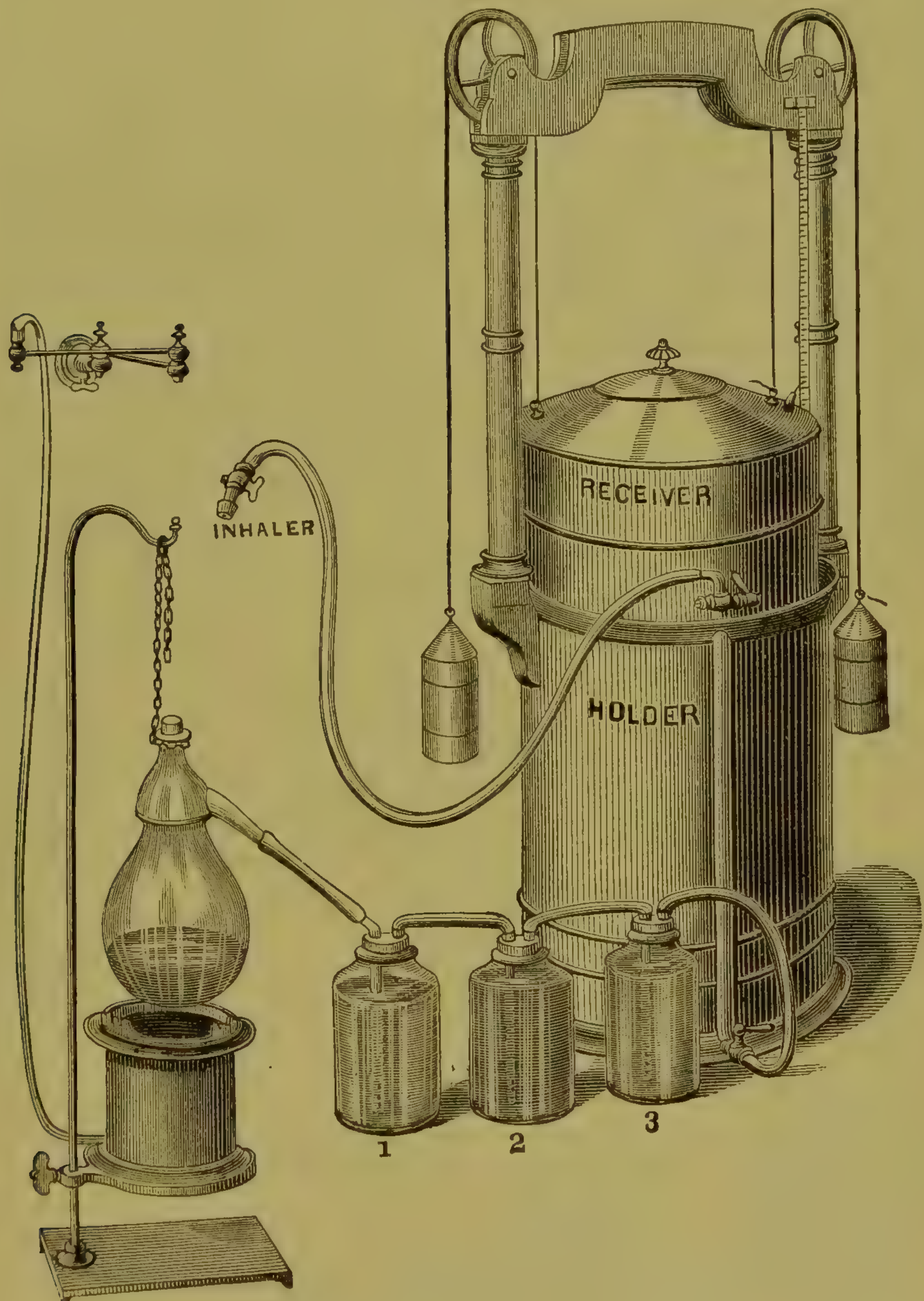
Wash-bottles.—The wash-bottles represented in the cut are $11\frac{3}{4}$ inches in height and have a capacity of $9\frac{1}{2}$ pints. They are closed with cone-shaped rubber stoppers, each containing two perforations large enough to admit, under pressure, glass tubes half an inch in diameter. These tubes are intended respectively for the admission and exit of the gas. The admission or dip tubes are made long enough to pass nearly to the bottom of the wash-bottles; the exit tubes are much shorter, as, in order that the outflow of gas may not be obstructed, it is necessary that their lower ends should be entirely above the surface of the washing fluids. The lower end of the dip tube is sometimes made somewhat bulbous, and with numerous small perforations designed to break up the gas in small volumes, and thus secure its more thorough washing. As, however, in practice the gas is usually found to escape through the more accessible of these openings, leaving the others unused, the device is not of much practical utility.

The amount of fluid placed in each bottle should be so graduated that in no case shall the end of the dip tube be more than two inches below

its surface, as where this depth is exceeded the column of fluid which will rise in the tube will offer so much resistance to displacement by the gas as to prevent free delivery.

The upper ends of both tubes are bent at right angles. The dip tube

FIG. 14.



Nitrous Oxide Gas Apparatus.

in bottle No. 1 is connected directly with the retort, and the short or exit tube in bottle No. 3 with the gasometer. From bottle to bottle the same relative arrangement is followed. These connections are all made by stout rubber tubing of suitable length and calibre.

The gasometer is constructed of sheet zinc, japanned to prevent chemi-

cal action. It may be made of any required capacity, from fifty gallons upward, according to the needs of the operator. It consists of the usual water-holder and gas-receiver, with pulley-and-weight attachment for counterbalancing. Before filling the gas-receiver all air should be expelled from it by opening its exit tube and sinking it in the holder, the latter being previously filled to within two or three inches of its top with pure spring or river water.

Washing Fluids.—The washing fluids used are the following: For bottle No. 1 (nearest the retort), pure cold water; for bottle No. 2, a solution of caustic potassa, made in the proportion of one drachm of the alkali to two pints of cold water; for bottle No. 3 (nearest the gasometer), a solution of ferrous sulphate, made in the proportion of two ounces of the salt to a pint of water. This solution should be made and kept cold. For greater security a fourth bottle, containing pure cold water, is sometimes added to the series.

Testing Joints.—When all connections are made between the retort, wash-bottles, and gasometer, accuracy of adjustment should be tested by blowing air through the whole system, beginning at the retort. If the proper adjustments have been made, the air will freely bubble up through the bottles and the gas-receiver will be lifted. The absolute impermeability of all joints, stopcocks, etc. is essential to success in making and storing pure nitrous oxide; and the fact that such impermeability exists should be definitely ascertained before the decomposition of the ammonium nitrate begins.

Quantitative Results.—The quantity of this salt to be placed at one time in an alembic of five pints' capacity should not exceed a pound and a half. This will make about fifty gallons of gas, the average product from a pound of ammonium nitrate being from twenty-five to thirty gallons, this amount varying with the temperature at which it comes over, as well as that at which it is maintained in the receiver. The quantity absolutely secured is very generally reduced by unavoidable wastage and by being taken up into solution by the water of the wash-bottles and gasometer.

Heating Appliances.—For heating purposes the ordinary illuminating gas, so mixed with air as to ensure perfect combustion, is convenient and effective. Many patterns of burners are now in the market. Instead of these a charcoal furnace—or, indeed, any of the usual sources of heat—may be utilized, the retort, suspended by its chain, being swung for a time to and fro through or over the flame, which is of course graduated as to size and intensity to guard against a too sudden or unequal heating of the glass surface.

Temperature of Decomposition.—Although the temperature at which the decomposition of ammonium nitrate is effected is of great importance, a thermometer is rarely employed as a guide: the experienced operator readily determines by such obvious physical phenomena as the greater or less violence of ebullition of the melted salt, the colorlessness of resultant products, etc. whether the decomposition is proceeding satisfactorily or otherwise. Indeed, the use of a thermometer in the retort is attended with considerable inconvenience and risk, as it is necessary that the bulb should be kept immersed in the ammonium nitrate, for the

reason that the temperature of the vapor or gas in the head of the retort is in all safe distillation 120° or 130° below that at which the salt decomposes, the amount of heat which this difference represents being absorbed by the products of decomposition as they pass into the state of gas or vapor; hence a thermometer in the head of a retort will rarely indicate a temperature of more than 200° F., even when distillation is proceeding most actively.

When an open flame is employed, its size must be gradually lessened or its distance from the retort increased as the volume of ammonium nitrate diminishes by decomposition, because just as a small flame, which would simply warm a large metallic mass, would heat to incandescence a piece of foil or wire, so the amount of heat which in a given time is rendered latent in liquefying and volatilizing a pound of ammonium nitrate far exceeds that which can be safely applied when the pound has been reduced to an ounce.

Between 270° F. and 300° F. the ammonium nitrate slowly sublimes without decomposing and without becoming fluid, a film of the sublimed crystals collecting in the head or beak of the retort or alembic. At 320° F. it slowly melts and decomposes, as evidenced by the appearance of occasional bubbles of gas. Between 340° and 480° F. the decomposition proceeds very rapidly, and is followed by free ebullition. The character of this phenomenon is a safe guide as to the nature of the decomposition which is being effected. It should never amount to a violent boiling, dashing the melted mass to the sides and top of the retort, but should be a free, gentle, and uniform bubbling of the gas up to the surface. A too violent ebullition indicates quite as unerringly as would a thermometer a temperature so high that combinations of nitrogen other than nitrous oxide may be formed, while the actual presence of such combinations is made manifest by certain changes of color in the contents of the retort.

Deleterious Products.—The exact nature of some of the chemical combinations in question has not been definitely determined. Ammonia and ammonium nitrite may be produced, but their vapor, like nitrous oxide itself, is colorless. A white cloudiness which often appears is probably due to the volatilization of ammonium nitrate, and possibly also ammonium nitrite formed from the nitrate. The red fumes which are always given off at a sufficiently high temperature are known to be due to the presence in the retort of either nitric oxide or nitrous acid.

Whatever may be the exact chemical structure of the products of the decomposition at the higher temperatures of ammonium nitrate, all are irritant and irrespirable, and some of them poisonous gases or vapors. These, if produced only in small quantities, may be removed during their passage through the chemical solutions in the wash-bottles.

Purification.—The pure cold water in bottle No. 1 will condense the steam which comes over with the gas, and will dissolve solid particles of ammonium nitrate or ammonium nitrite which may escape from the retort. Ammonia too will be taken up into solution.

The caustic potassa in bottle No. 2 combines with nitric and nitrous acid, carbonic acid, and chlorine.

The ferrous sulphate in bottle No. 3 will absorb any ammonia which

may have escaped from the other bottles, but its chief value is that it has a special affinity for nitric oxide (NO), with which, according to Péligot, it forms the following compound: $2FeSO_4 + NO$. This compound, however, is readily decomposed by heat; hence the necessity for keeping bottle No. 3 and its contents cool.

While these chemical agents are reasonably certain to remove all products of decomposition other than nitrous oxide, provided they be not produced in too great volume, the best assurance of safety lies in so regulating the temperature that only that gas and water shall be formed. This is especially necessary when the gas is to be at once liquefied, because there is then but little opportunity afforded for the removal of nitric oxide by absorption in the water of the gasometer; which absorption will be readily effected if the water contains air, as in greater or less proportions it always does, the absorption being dependent upon the oxidation of the nitric oxide (NO) to the nitrogen dioxide (NO_2), which is readily soluble in water.

The wash-bottles should not be connected with the gasometer until the nitrous oxide has begun to pass freely through them, thus expelling the air which they contain. When the gasometer is to be freshly charged, however, or when it is known to contain either impure gas or atmospheric air, the escape-pipe should be opened, the wash-bottles connected, and the newly-formed gas be allowed to pass through and escape from not only them, but the receiver as well. After a few minutes, if the nitrous oxide is coming over freely, only pure gas will remain and the escape-pipe may be closed.

Pressure during Distillation.—As the initial velocity of the gaseous molecules entering the gasometer supplies the lifting force necessary to raise the receiver, and as this force is transmitted equally in all directions and exerts the same pressure on all equal surfaces, the original impulse or series of impulses, although very slight, is, when thus multiplied, sufficient, if time be given, to lift the largest receiver, when properly counterbalanced, without any notable increase of pressure inside the retort. Care should be taken, however, not to pass the gas into the receiver beyond its storage capacity, as then the pressure is at once intensified, and either leakage at the joints or fracture of the retort may result.

Wastage of Gas.—As already stated, some wastage of gas is occasioned by its being taken up into solution by the water in the gasometer: this loss, as has been seen, varies with the temperature of the water, the amount dissolved being less when the water is warm than when it is cold—a fact which indicates the advisability of keeping the gasometer in a moderately warm room. Loss in this direction, however, becomes inconsiderable when the water has once been saturated, as it will be when contact has been maintained for several days.

Deterioration.—A more important consideration is the deterioration of the nitrous oxide which must result from such prolonged contact, for not only is nitrous oxide taken up by the water, but the gases with which all ordinary spring and river waters are charged become, by the laws of diffusion, mixed with the nitrous oxide, so that in a few days the latter becomes unfit for use. If administered, a larger amount of

the gas and a longer time are required to produce anæsthesia, and the inhalation is followed by headache and general malaise if by no more alarming symptoms. The gases present in fairly pure water are oxygen, nitrogen, and carbon dioxide. When sewage contaminations are present, chlorine, sulphuretted hydrogen, and such volatile organic acids and alkaloids as are among the products of the putrefactive decomposition of organic matter will be found, and in no inconsiderable quantity. Under no circumstances should water so contaminated be placed in the gasometer.

Storage of Gas.—The water in the holder, if pure, need not be changed, but loss by evaporation will necessitate occasional additions. When stored with nitrous oxide, with which gas it speedily becomes saturated, putrefactive changes in the water are never observed. This is probably due to the presence of the gas, which is antagonistic to germ-life. An operator of large experience, Dr. Thomas, states, however, that he always observes a deterioration in the quality of the nitrous oxide when it has been stored over water which has remained in the holder more than three weeks, the effects of the gas when inhaled being unsatisfactory in character. He therefore changes the water at frequent intervals. This, however, is not the usual practice, and the effects mentioned by Dr. Thomas have not been noted by other specialists.

As a rule, it is better not to administer nitrous oxide immediately after its collection, as any nitric oxide which may have escaped solution or chemical arrest in the wash-bottles will, after a few hours of contact, be dissolved in the water of the gasometer, which always contains free oxygen absorbed from the air of the room.

The temperature at which the gas is stored may easily be too high for immediate administration if the proper precautions have not been observed in its preparation. Usually, however, this is not the case. Owing to the presence with it of so large an amount of steam, the gas passes into the first wash-bottle at a temperature not much above 212° F., and by the time it has reached the gasometer its temperature will have been reduced to about that of the washing fluids through which it has passed. With these fluids at a temperature of 40° F. at the beginning of the passage of the gas through them, the writer has observed a rise of only ten degrees in the temperature of the contents of the third wash-bottle after all the gas resulting from the decomposition of a pound and a half of ammonium nitrate had passed through it. Were the process to be indefinitely prolonged, however, it is obvious that ultimately the temperature of the gas as it passed into the receiver would become but little less than that in the retort; which condition would, of course, absolutely inhibit its administration.

Temperature for Administration.—Under all circumstances the gas should be thoroughly cool, as it is a matter of clinical experience that when given even moderately warm the effects are not so satisfactory as when administered at the lower temperature—a result doubtless due to the greater rarefaction of the gas when heated, the volume of this, as of all other gases under a constant pressure, varying, in accordance with the law of Charles, directly as the absolute temperature.

Assuming that the number of molecules of nitrous oxide in the whole

amount of gas made remains the same, however much the volume of the gas may be amplified by heat or diminished by cold, it follows that when the volume is increased the molecules must be more widely separated the one from the other, and that, as a consequence, a smaller number of these will enter the lungs at each inhalation. Thus, fewer being admitted, fewer will be absorbed in a given time, and insufficient dosage must result in insufficient anæsthesia.

LIQUEFIED NITROUS OXIDE.—As already stated, nitrous oxide assumes the liquid form when subjected to a pressure of fifty atmospheres at a temperature of 40° F. Gas stored in this condition may be kept for an indefinite period perfectly free from all sources of contamination. This advantage, among others, has caused its general introduction into dental practice, and, with the exception of those who daily use large quantities of the gas, but comparatively few now resort to the older methods for its manufacture and storage.

The making of nitrous oxide upon the large scale required for commercial purposes differs only in detail from the processes already described. The retorts are made of iron lined with porcelain; the tubing leading to the wash-bottles is also of iron, with a segment of glass introduced through which the appearance of the products of decomposition may be examined.

The gas as formed is conducted into a large iron gasometer, whence it passes to the condensing pump, of which there are various forms in use. This must be constructed with the utmost precision of adjustment, as the absolute impermeability of all joints and the perfect working of valves are necessary to prevent the wastage of gas.

Charging Cylinders.—The nitrous oxide passes directly from the pump into wrought-iron cylinders of varying size, into the smallest of which one hundred gallons, and into the largest five hundred gallons, of gaseous nitrous oxide may be condensed. As the pressure to which the cylinders are subjected is enormous, the utmost care is requisite in the selection of material for their manufacture, iron of the highest possible tensile strength being employed and all joints being thoroughly welded. Each is tested by pressure far exceeding that to which it will be subjected in the storage of nitrous oxide.

The cylinder to be charged is connected directly with the condensing pump, and placed in a tank filled with ice and water, to keep the temperature of the gas down to the required point. Owing to the large amount of heat evolved from the nitrous oxide in its passage from the gaseous to the liquid state, the process cannot be hastened, and with a condensing pump operated by steam about fifteen minutes are required to fill a one-hundred-gallon cylinder.

Each cylinder is provided with a high-pressure gas-valve, which when in order will effectually seal its contents, and through which the gas may be withdrawn from time to time in such quantities as may be needed.

TESTS FOR NITROUS OXIDE.—The purity of any given volume of nitrous oxide gas may be determined by the following tests:

Acids.—As a general test for all acid contaminations, pass the gas through a solution of litmus: any acid vapor present will turn the litmus from its natural blue to a red color.

Alkalies.—A solution of litmus reddened by an acid may be used as a test for alkaline impurities, such as ammonia, etc.: by these the blue color is restored to the solution.

Carbonic Acid.—Lime-water will give with this acid a white precipitate of calcium carbonate.

Chlorine and Hydrochloric Acid Gas.—These and the chlorides will cause a precipitation of silver chloride from a solution of silver nitrate.

Nitric Oxide.—This gas will give a dark-brown color to a solution of ferrous sulphate.

Iodine and Starch Test.—The presence of ozone, chlorine, hypochlorous acid, and nitrogen oxides higher than N_2O will be indicated very delicately by placing in the gas a paper freshly dipped in a solution of potassium iodide in liquid starch: the paper will turn blue upon the liberation of iodine by any of the above substances.

The writer has carefully tested the liquid nitrous oxide furnished by by the S. S. White Manufacturing Company, Philadelphia,[1] and has failed to demonstrate the presence of any impurities whatever. For all practical purposes it may be considered as chemically pure. The same is probably true of the liquid gas prepared elsewhere.[2] These results are doubtless largely due to the care exercised in the manufacture of ammonium nitrate and in its distillation.

Pressure as a Purifying Agency.—The claim is frequently made that the liquefaction of nitrous oxide is in itself eliminative of such other gases as require a higher pressure to effect their reduction from the gaseous to the liquid state. That a *separation* of mixed gases may be effected by subjecting the mixture to varying rates of pressure is unquestionable, but the elimination of the separated gas is not a necessary result of its separation, and, withal, is not so readily accomplished.

Of all known gases, nitric oxide is one of the most difficult to liquefy, a far greater pressure than fifty atmospheres being necessary. Assuming that nitrous oxide under pressure is contaminated with nitric oxide, the latter substance would retain its gaseous form under the pressure of fifty atmospheres, which would completely liquefy the nitrous oxide. But, as already intimated, this separation can be a matter of but little practical consequence so long as the two substances still remain in, and are drawn off from, the same cylinder or other receptacle into which they have been forced.

Thus confined in the cylinder, a minute amount of nitric oxide might possibly be held in solution in the liquid nitrous oxide, but the greater volume will probably be found intimately mixed with the vapor of nitrous oxide, which always exists above the liquid portion in the cylinder.

On this hypothesis it would seem that if this contaminated residual nitrous oxide vapor is allowed to escape before applying the remaining

[1] To this company the writer is indebted for the courtesy of a full explanation of their methods of preparing the gas.

[2] In France tests for impurities applied by M. Cazeneuve gave equally negative results. He states (*Lyon Médicale*, Dimanche, 2 Novembre, 1884) that all specimens of liquefied gas he has examined are almost absolutely pure. Only a trace of oxygen (probably from air) is found, and there is an entire absence of deleterious nitrogen compounds.

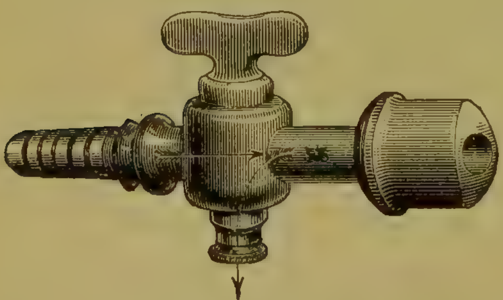
contents of the cylinder to anæsthetic purposes, the *elimination* of nitric oxide would in a great measure be effected. As the writer is not aware that this practice is systematically followed by manufacturers, it can be recommended as a wise precaution on the part of administrators.

INHALING APPARATUS.—Nitrous oxide may be inhaled either directly from the gasometer by means of a mouthpiece with suitable valves and tubing, or it may be drawn into an air-tight bag provided with a mouthpiece and stopcock, and be thence drawn directly into the lungs of the patient. The latter method was the earlier one, and is still adhered to by some operators. It is, however, open to the objection that unless the mouthpiece be provided with valves the products of expiration will, the nasal passages being closed, pass back into the bag, diluting and contaminating its contents. In practice, however, the operator can to a great extent obviate this objection by compressing with his fingers the nose of the patient during the inspiratory movement and removing the pressure during expiration, thus allowing the greater portion of the lung contents to escape through the nasal tract. By practice considerable dexterity in the performance of this valvular manipulation can be acquired, the chief difficulty being in so timing the compression and release of the nose as to make these movements synchronous respectively with the inspiratory and expiratory acts.

For convenience and effectiveness, however, a system of valves working automatically in the inhaler is to be preferred. These valves, in whatever manner made, should be so perfectly adjusted as to, as nearly as possible, absolutely exclude atmospheric air while admitting full volumes of the anæsthetic gas and preventing the return into the gas-bag or receiver of the products of expiration.

A simple and yet effective form of valved inhaler is that seen in Fig. 15. It is made of hard rubber, the inner diameter of the tube being somewhat over half an inch. The entrance and exit valves are made of thin disks of hard rubber. With the stopcock seen in the illustration the supply of gas can be regulated at the will of the operator. To prevent the admission of air by way of the nasal tract the nose of the patient must be compressed by the operator during the administration of the gas. A clamp may be used, but the fingers are more effective.

FIG. 15.



Hard-rubber Inhaler.

Next in importance to the proper construction and perfect working of the valvular apparatus is the adaptability of the mouthpiece to the uses for which it is designed. A frequent defect is the small calibre of the tube. For adults this should always be between a half and three-quarters of an inch in diameter, so that full and free volumes of gas may pass into the lungs at each inspiration. As the adult human trachea has a diameter of from three-fourths of an inch to an inch, the desirability of approximately conforming to this natural measurement

Fig. 16.


Improved Flexible Facepiece.

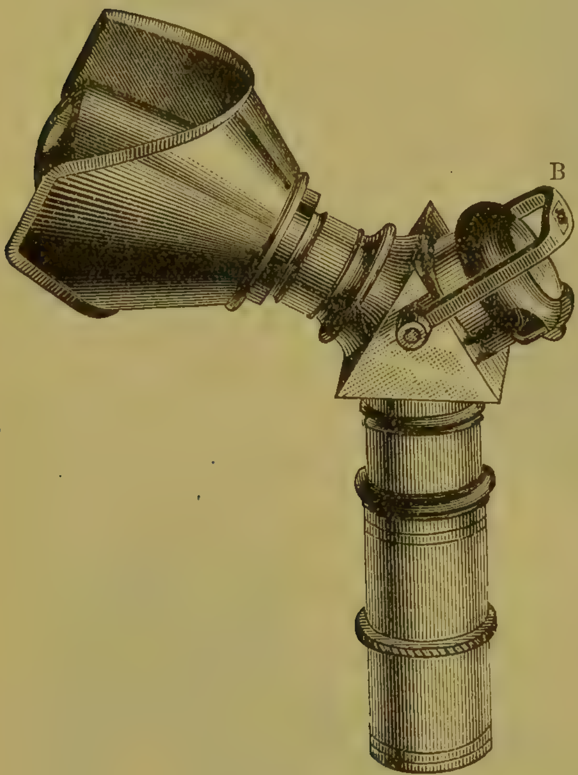
is apparent. The hard rubber of which mouthpieces are constructed is a material admirably adapted to the purpose, it being light, strong, and cleanly.

Many inhalers are provided with a metallic mouth-hood, such as that seen in Fig. 17. The writer has not found mouth-hoods generally advantageous: they completely obscure the lips from view, so that changes in their color cannot be observed, and as they, of course, do not accurately adapt themselves to all facial contours, air will frequently pass beneath them and into the lungs unless the lips of

the patient be tightly compressed around the mouthpiece; and this the presence of the hood prevents the operator from definitely determining, thus introducing an element of incertitude into the anæsthetic procedure.

A much more practical form of hood or facepiece is the "improved flexible facepiece"[1] seen in Fig. 16. This hood is designed for use without a mouthpiece. It is made of soft rubber, with an inflatable edge-cushion attached to a metal frame which is screwed to the inhaler. This cushion may be inflated by means of the little tube seen in the figure, which tube is provided with a closely-jointed stopcock. The flexibility of this hood permits of its accurate adjustment to the face, and as it covers the nose, compression of that organ either with the fingers or with a clamp can be dispensed with. In cases of hare-lip or when from any cause there is immobility of the temporo-maxillary articulation, the flexible hood is of admirable service; but for general purposes the writer prefers the plain mouthpiece, in the use of which neither the lips nor any other portions of the face are hidden from view.

FIG. 17.



Divested of the mouth-hood, which may readily be detached, the inhaler seen in Fig. 17[2] is admirably adapted for its purpose. With the exception of the mouthpiece and two valves, which are of hard rubber, it is constructed entirely of metal.

Both the inhaling and exhaling valves are placed in a prism-shaped casting, A (Fig. 18), which is an improvement on the two-way cock usually employed, and which affords the additional advantage of an angle in the apparatus whereby the tubing is permitted to fall close to the breast of the patient, out of the way of the operator. The valves are controlled externally by a stirrup or bow, B (Figs. 17, 18, and 19), to which is attached, inside the prism-shaped box, by means of a shaft, a foot-shaped cam, C. When the bow is pushed upward in the position shown in Fig. 18, the heel of the cam presses against and holds open the exhaling valve, D, allowing free passage of the air to and from the lungs, while at the same time the toe of the cam closes the inhaling valve, E, and prevents the escape of gas from the reservoir. When the bow is pushed backward, as shown in Fig. 19, both valves are thrown into

[1] Of the S. S. White Dental Manufacturing Company.
[2] Gas-Inhaler No. 2 of the S. S. White Dental Manufacturing Company.

action, and become subject to the slightest breath of the patient, inhalation opening the gas-valve and closing the air-valve, exhalation producing the reverse effect.

When a gas-bag is used, it should be thoroughly emptied of air before the nitrous oxide is passed into it: this can be quite perfectly accomplished simply by the inhalation of its contained air by the operator. The same method should be adopted with the delivery-pipe when the gas is to be inhaled through it direct from the receiver: a short pipe is readily emptied in this manner, and, as it is undesirable that any great length of tubing should be used, the gasometer should not be placed more than five or six feet from the patient.

Fig. 18.

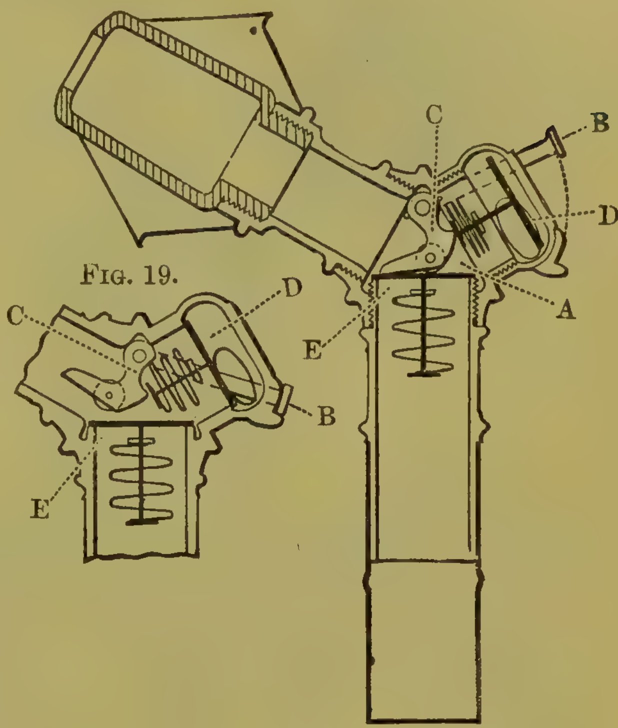
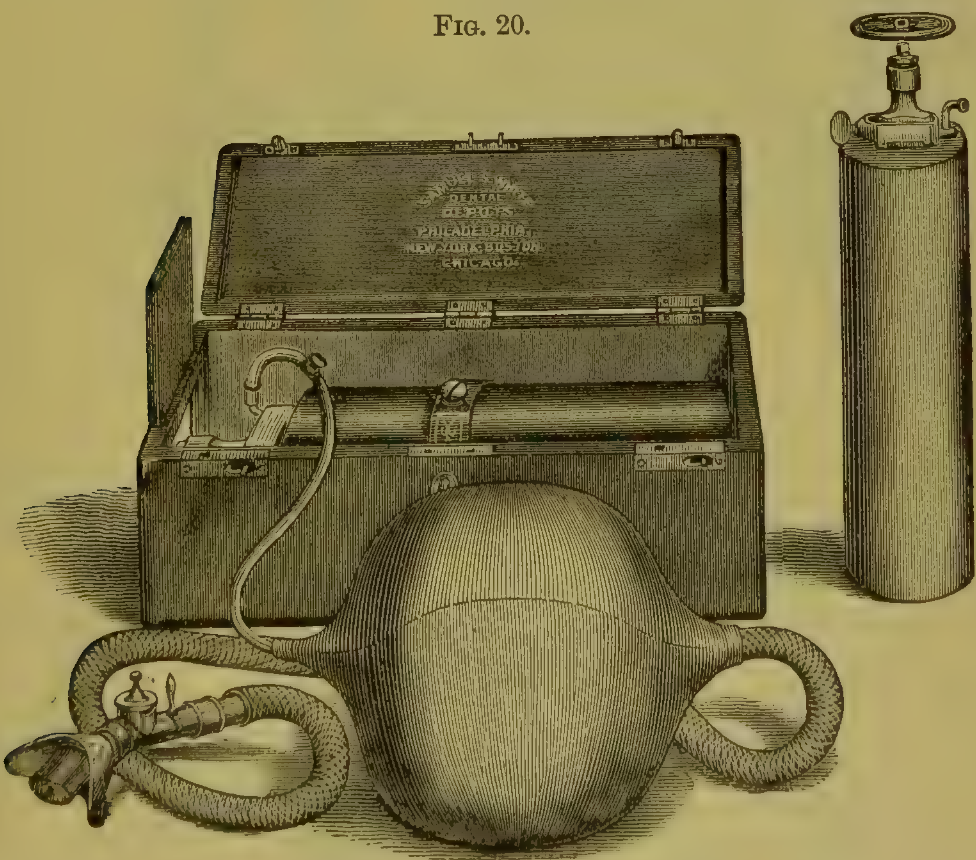


Fig. 19.

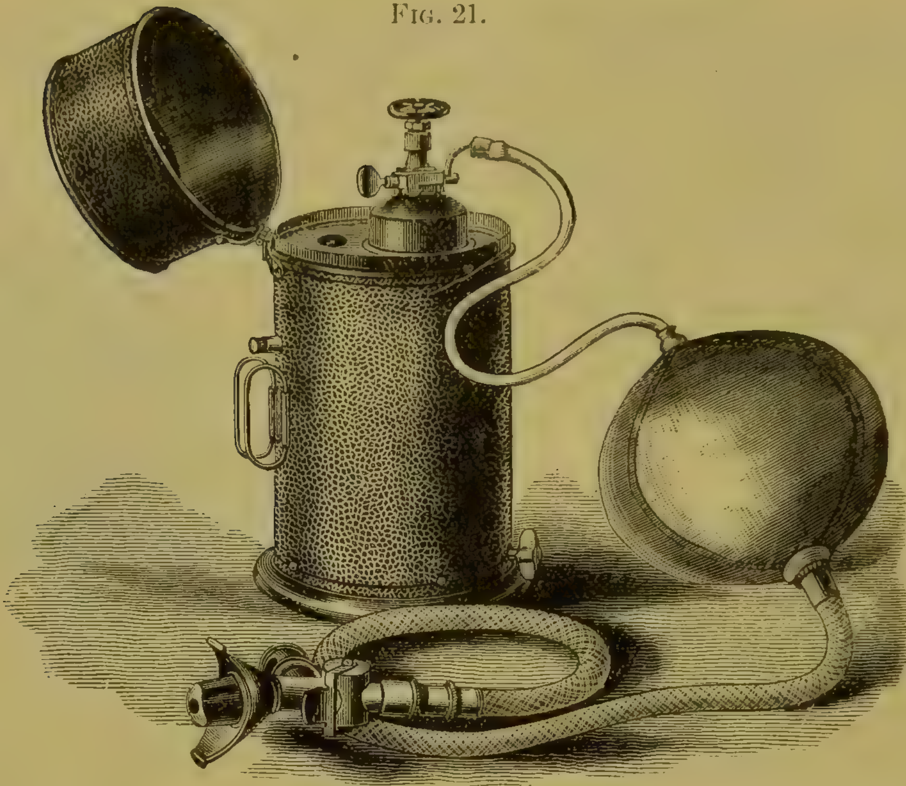
In the use of the liquefied nitrous oxide the gas may be drawn from

Fig. 20.



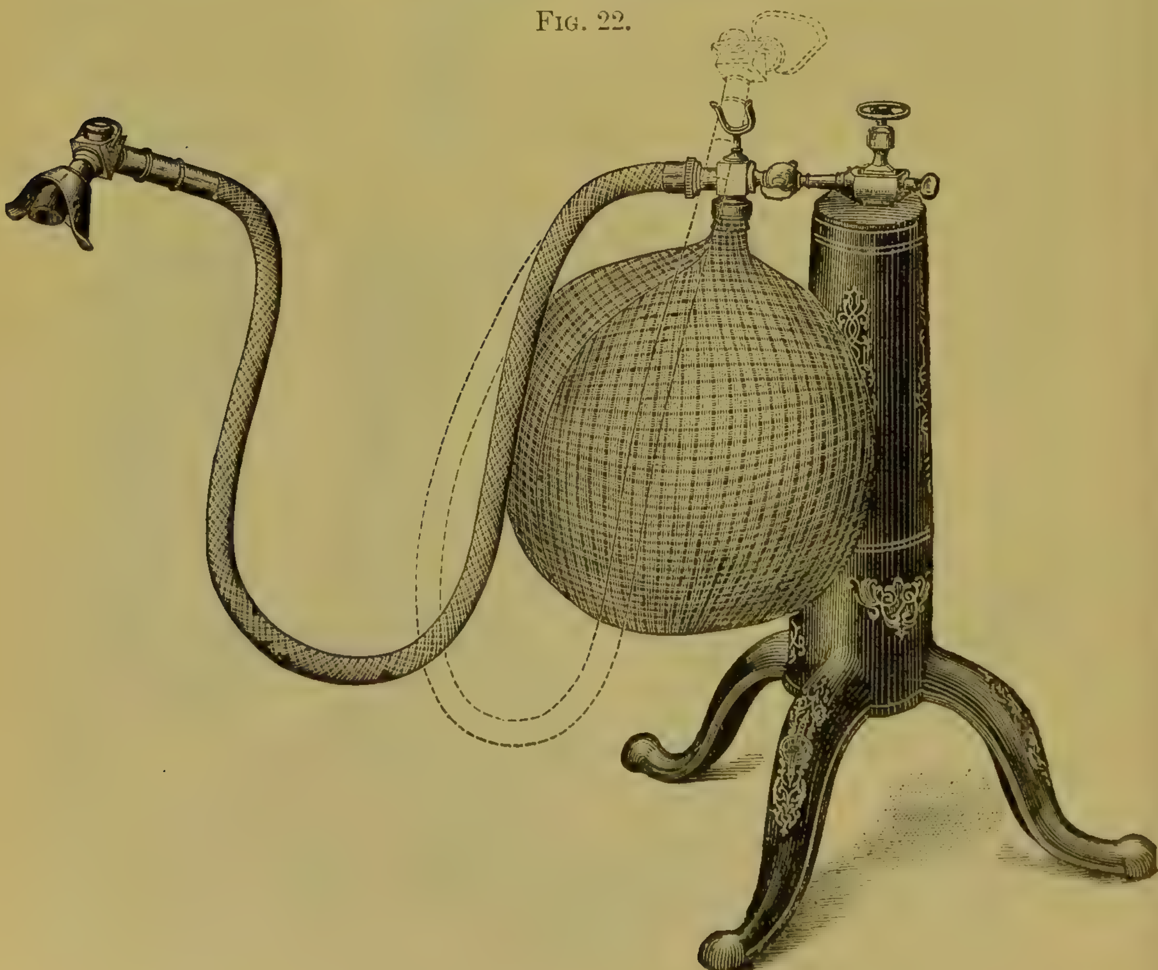
Surgeon's Case.

FIG. 21.



Upright Surgeon's Case.

FIG. 22.

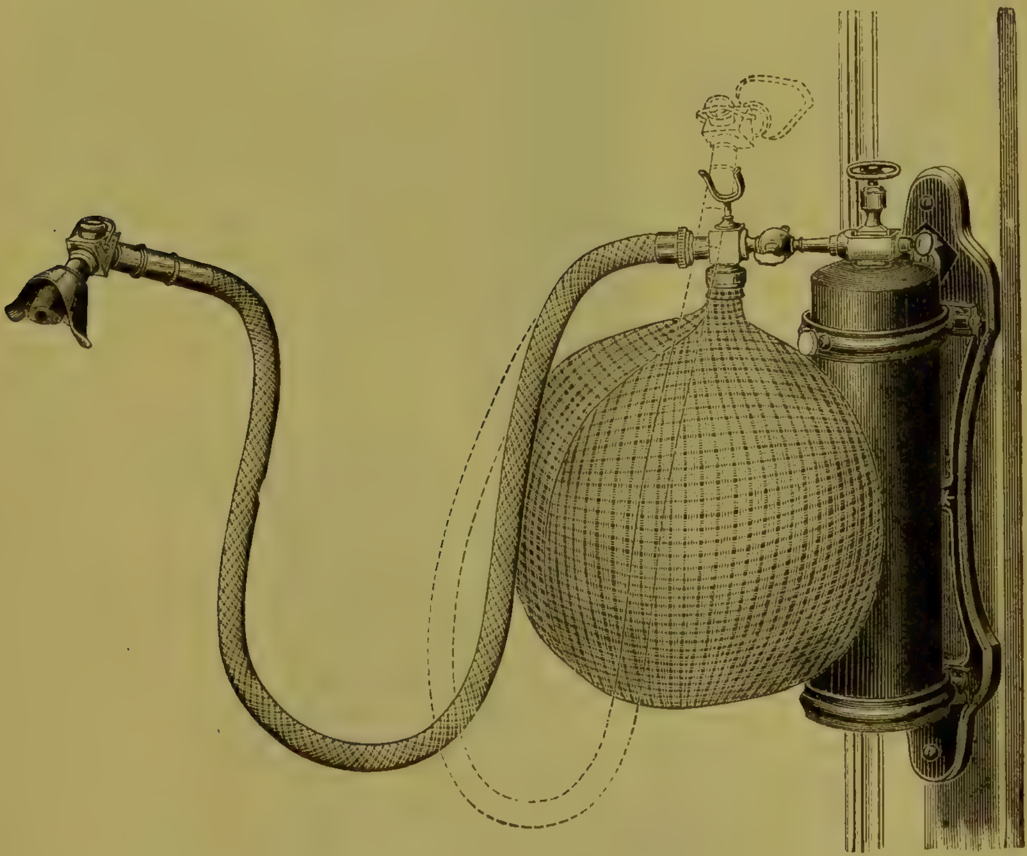


Stand for Gas-cylinder, with Yoke-Attachment.

the cylinder directly into an air-tight bag of suitable capacity—six to eight gallons. For greater convenience this bag is generally connected by tubing at either end with the cylinder and inhaler respectively. By this arrangement a fresh supply of gas can, when needed, be passed into the bag without the removal of the inhaler from the mouth of the patient.

In Figs. 20 and 21 are seen two forms of apparatus for the storage and administration of liquefied nitrous oxide, which forms, being portable, are well designed for the use of the general surgical practitioner. In Fig. 20 the cylinder containing the gas is placed in the case in a horizontal position. In Fig. 21 it stands on end, and is somewhat more accessible.

FIG. 23.



Wall-Bracket for Gas-cylinders.

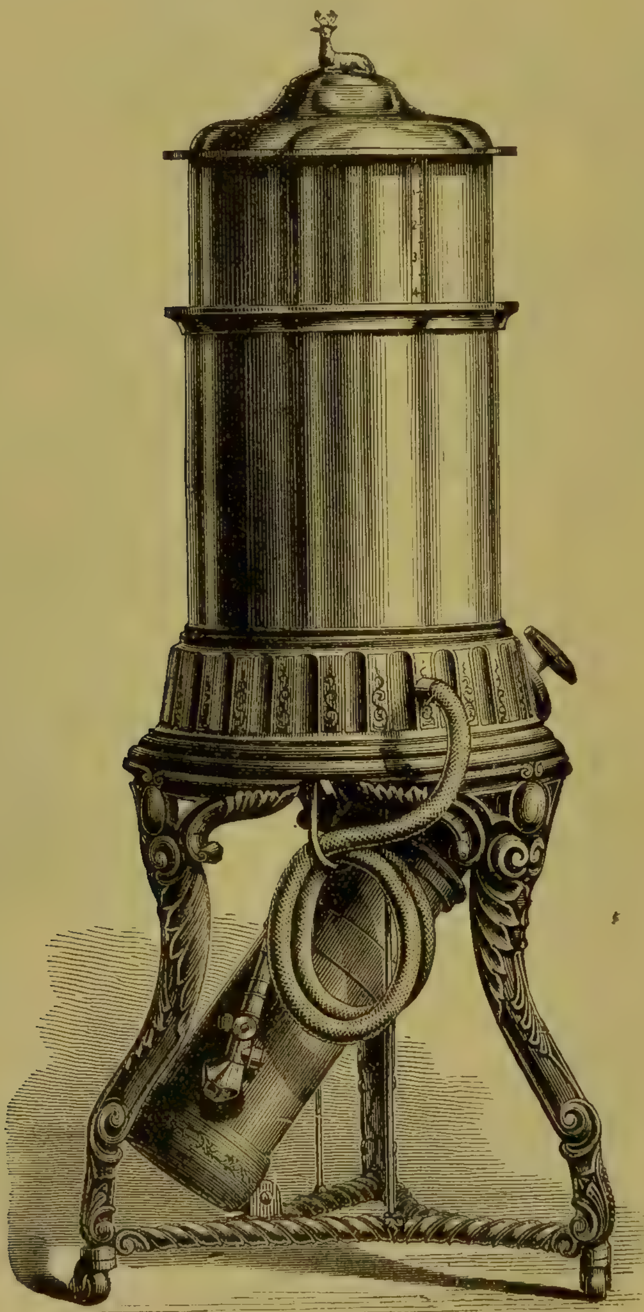
Figs. 22 and 23 represent forms of apparatus adapted for office use. Fig. 22 shows a metallic stand containing the cylinder, with the gas-bag held in position by a "yoke attachment." The yoke is provided with a holder for the inhaler when not in use, as shown in the dotted lines. In Fig. 23 is seen a form of wall-bracket for a gas-cylinder, the latter having the same equipment as that seen in Fig. 22.

Another form of apparatus now coming into extensive use is that seen in Fig. 24. It consists of a small metallic gasometer with a storage capacity of about ten gallons of gas. Into this, instead of an elastic bag, the gas is passed by means of the key seen on the right of the figure. By simply turning the key the operator has under his control all the gas in the cylinder, a scale graduated in gallons and fractions of

a gallon, attached to the bell, enabling the operator to determine how much gas has been used. Surplus gas can remain in the gasometer for several days if necessary, and still be available for use.

The diagram (Fig. 25) represents a sectional view of a Johnston gasometer. Two metallic cylinders, A A, are arranged concentrically to form a water-holding space between their proximal walls, while a third cyl-

FIG. 24.

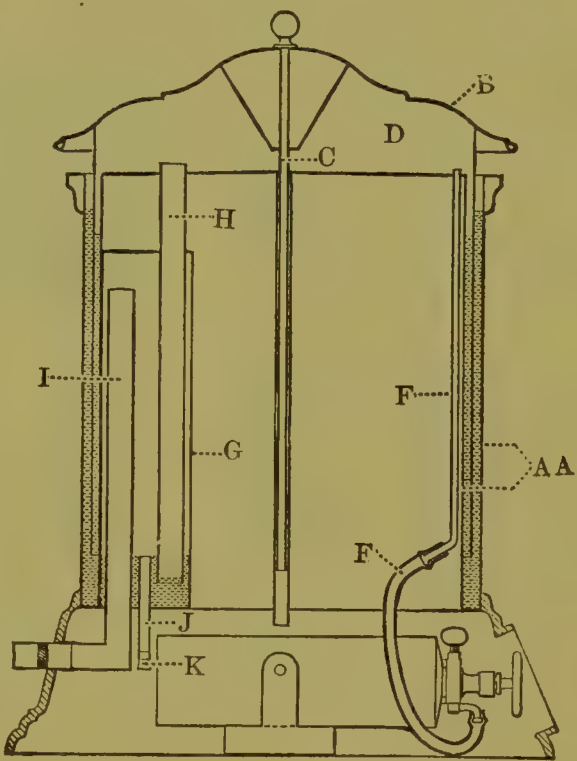


Gasometer and Stand.

inder, having a cover, B, and a guide-rod, C, attached to the cover, is lowered into the water-space as a seal between the cylinders and to form a gas-chamber, D, at the top. The inner cylinder is provided with a central tubular cavity, closed at the bottom, to receive the guide-rod of

the cover. It is obvious that the chamber, D, will be enlarged or diminished according to the volume and presence of the gas which rises to the chamber from the iron cylinder, E, beneath the gasometer, when the valve is opened, through the connecting tube and pipe, F, F. The gas is conducted to the inhaler from the chamber, D, through a closed cylindrical water-vessel, G, attached to the wall of the inner cylinder, and provided with an inlet-pipe, H, and an outlet-pipe, I; which latter is carried to the outside at right angles to the gasometer, and receives the tubing which conducts the gas to the inhaler. This closed vessel, G, is also provided with a water-outlet or overflow, J, and the whole forms a very simple and effective trap for shutting off the gas when not inhaled. In operation it is only necessary, before the cover is placed in position, to pour into the water-space between the cylinders enough water to nearly fill it, and into the inlet-pipe, H, sufficient water to overflow the outlet, J, of the trap, the rubber stopper, K, of the latter being removed for that purpose and replaced when the overflow has ceased. Then insert the cover and open the valve of the iron cylinder beneath. The vacuum in the vessel, G, produced by each inhalation is immediately filled by the gas passing through the water and upward to the outlet, I; the instant that inhalation ceases the gas is arrested and confined at the water-level in the trap. This gasometer is also provided with a gauge, which indicates by gallons the quantity of gas in the reservoir.

Fig. 25.



Preparation of the Patient.—The almost entire immunity from fatality which has hitherto attended the administration of nitrous oxide for anæsthetic purposes has resulted in a carelessness in regard to the preparation of the patient which is to be deprecated. Even with nitrous oxide anæsthesia is a condition of danger, and while this is less than with any other known anæsthetic, still an utter disregard of all the rules ordinarily to be observed in the use of other agents of the same class is not to be justified.

In order that respiration may be free, and that prompt measures may be taken for the rescue of the patient from syncope or asphyxia, either of which may occur during the operation, the clothing should be loosened. As nausea is of very rare occurrence, an absolutely empty stomach need not be insisted upon, but it should not be distended with food, neither should the bladder or intestines be overloaded. As a rule, it is

better that a period of from two to four hours should have elapsed after the last meal. That all foreign substances should be removed from the mouth is, of course, self-evident. The one great departure from the general laws governing the anæsthetic procedure is in the position of the patient: with nitrous oxide gas the sitting posture may, for short operations, be maintained throughout. This departure from a general principle is justified by the fact that the heart and circulation are but slightly influenced by the agent, and that it at no time exerts a specifically depressing power over the cardiac ganglia. The head of the patient should be bent forward rather than backward, as thus placed there is less danger that the tongue will fall back and close the glottis. The hands should be spread out in full view, either upon the lap of the patient or upon the arms of the chair in which he is seated, thus facilitating the observation of those changes of color which are so significant in narcosis with this agent.

Props.—Prior to the administration of the gas a gag or prop should be placed between the teeth of the patient. This is made necessary by the muscular rigidity which usually marks the stage of complete anæsthesia when nitrous oxide has been employed. When the operation required is the extraction of teeth, much valuable time might be lost in forcing apart the jaws of the patient were the prop not in position. But even for operations other than in the mouth its use cannot, ordinarily, be safely dispensed with, as by keeping the mouth open it enables the operator to grasp and draw forward the tongue or thrust his fingers into the fauces when profound stertor or other indications of approaching asphyxia indicate the necessity for the removal of mechanical obstructions in the air-passages or of reflex stimulation of the respiratory function.

The prop should always, when possible, be placed between the molars, and in cases of extraction upon the side opposite to that from which the tooth is to be removed. Placing it between the incisors is, of course, for every reason undesirable: it would interfere with the introduction of the mouthpiece when one is employed, and if pressed upon too strongly might cause the fracture of these relatively frail and conspicuous teeth; indeed, one of the uses of the prop is that it affords a good degree of security against the occurrence of this accident through pressure upon the mouthpiece of the inhaling apparatus.

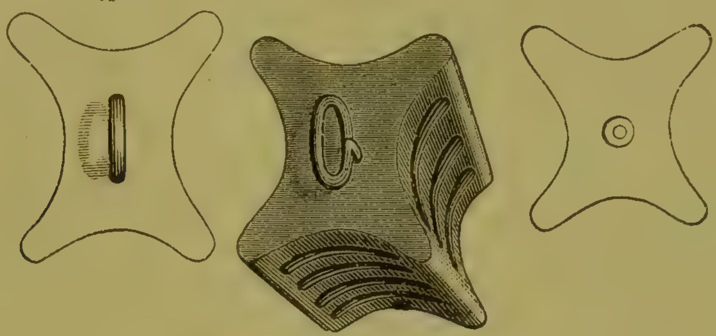
The length of the prop must be regulated by the conditions of the case, the extent to which the jaws can be parted varying greatly in different individuals, even in health, and being often seriously limited by pathological states of the teeth or their investments. In cases of simple extraction all that is required is that the jaws shall be sufficiently separated to permit the free introduction of the extracting instrument and the safe removal of the tooth: all extension beyond this is unnecessary and, if discomfort is occasioned, harmful.

The prop should be made of hard wood, hard rubber, cork, or of some other substance not easily fractured, and it should be grooved or serrated in order that it may not readily slip from between the teeth. For security against accident the prop should invariably have attached to it a strong string, so that in case it should become displaced and fall

into the fauces it may readily be removed. At least one case of fatality is attributable to a neglect of this precaution.

One of the most practical forms known to the writer is that devised by Dr. F. T. Van Wert of Brooklyn, N. Y., and illustrated in Fig. 26.

A FIG. 26. B



It is constructed of tough black rubber, and is deeply grooved upon its four sides, each groove being serrated. In general outline the prop is wedge-shaped, A showing in cross-section the large end, B the small end of the wedge. Thus the prop is made to conform to the dimensions of the space between the teeth when the jaws are opened, so that when the small end of the wedge is placed between the upper and lower molars the large end will be in contact with the more widely separated upper and lower bicuspids. As the diameters of the wedge are unequal, this single prop can be adapted to quite a wide range of requirement as to the separation of the jaws, and its form admirably adapts it to those cases in which, owing to the absence of teeth upon one side of the mouth, it is necessary to place it in contact with the gum-tissue of the edentulous alveolar ridges. A looped wire strongly bolted to the prop affords a convenient means of attachment for the string.

PHYSIOLOGICAL EFFECTS OF NITROUS OXIDE.—The first obvious impression resulting from the inhalation of nitrous oxide is upon the gustatory sense by the characteristically sweetish taste of the gas. While, when perfectly pure, nitrous oxide is not irritative in the ordinary acceptation of the term, still the first full, deep inhalations produce in the respiratory tract an indefinable sense of oppression, sufficiently marked in character to frequently cause patients to thrust away the inhaler. These sensations are probably referable to the displacement of oxygen by the nitrous oxide, but may perhaps be in a measure due to the impact of the molecules of this gas against the delicate epithelium of the bronchial passages, to which they present themselves as foreign bodies, although not so markedly different in size, form, and chemical affinities from those inhaled in normal respiration as to produce distinctly irritative results. As, however, the nerves of sensation in the lung tract become almost immediately locally anæsthetized, the sense of discomfort is evanescent in character, and is speedily replaced by a feeling of well-being deepening into a glow of pleasurable emotion: a disposition to merriment and laughter is experienced. This in all its essential features corresponds to the first stage of ether narcosis, the stimulant stage or the stage of functional excitation.

If the administration of the gas be discontinued at this point, the exaltation of functional activity will sometimes be manifested in a very marked degree. The most violent muscular movements may be executed, often to the injury of the patient himself or of bystanders: violent rushes at imaginary foes, blows dealt against them; declamatory gestures; oscillations of the head from side to side with a violence threatening dislocation of the vertebræ; excessive laughter, drunken volubility, and maudlin weeping are among the effects, physical and psychical, which in former times were frequently witnessed when the gas was inhaled solely to produce intoxicant effects for purposes of amusement or of physiological experiment. As ordinarily administered for anæsthetic purposes, however, the stage of depression follows so swiftly upon the condition of excitation that opportunity is not afforded for the development of these phenomena, and it is but rarely that a patient requires the exercise of force for his control. Were the progressive phases of anæsthesia evolved as slowly with nitrous oxide as with ether, it is possible that restraint would be necessary quite as frequently with the former as with the latter agent.

As administered for anæsthetic purposes, however, the stimulant stage rapidly merges in the second or narcotic and anodyne stage of anæsthesia, during which a tingling sensation, followed by numbness, is felt over the entire cutaneous surface, the brain seeming to swim in dizzy and ever swifter gyrations; finally, in a whirl of confused and incoherent ideas and impressions consciousness is lost, and the narcosis deepens into the beginning of the third or true anæsthetic stage.

Effects on Circulation and Respiration.—The circulatory system, except in extreme narcosis, is, as a rule, but little disturbed; the pulse, if excited before the inhalation of the gas, grows calmer under its influence, while a normal pulse usually become slightly stronger and more frequent, and so remains until the termination of the anæsthetic process. As the narcosis deepens the respirations, which were at first slow and reluctant, become under the stimulus of insufficient oxygenation more rapid; the eyelids and the muscles of the face twitch convulsively; the eyeballs protrude; the lips assume a livid hue, and the entire face becomes first pallid, and then cyanosed, in which latter condition the whole cutaneous surface participates, the discoloration being easily observed around and under the finger-nails and other more delicate and vascular portions of the integument. The aspect of the patient is at this time ghastly in the extreme, there being every physical indication of impending asphyxia, the gravity of the symptoms being intensified by the stertorous character which at this point the respiration generally assumes. These appearances are coincident with an anæsthesia sufficiently profound for the needs of minor surgery, and the inhaler must be withdrawn and the operation swiftly performed.

It will be observed that while the third stage, or the stage of full anæsthesia, has been reached, it has not at the time indicated for the operation been so fully developed as is requisite for safety in operations under ether or chlorofrom narcosis, the most notable point of difference being that when the latter agents are employed complete relaxation of the whole voluntary muscular system must be attained, while nitrous

oxide, as ordinarily used, cannot be safely pushed beyond a point in which the general muscular system is still unrelaxed, the only exception being in the muscles of the tongue, to whose more or less complete paralysis, and the consequent contact of the organ with the vibrating velum, the snoring respiration of the patient is due. Were the administration of the gas pushed farther, complete muscular relaxation and a more profound anæsthesia would follow; but this result cannot be safely produced with this agent except under conditions to be presently described.[1]

The hemorrhage following an operation under nitrous oxide, given undiluted, is always more or less venous in character—a result due to the exclusion of oxygen from the respiratory tract. The venous hue is very noticeable in the bleeding following the extraction of a tooth: not only is the blood dark in color, but, owing to contraction of the arterioles, sluggish in outflow.

Time Required.—The average time required to anæsthetize a patient with nitrous oxide is rather less than a minute (Thomas), or, according to the observation of Mr. Charles James Fox, from fifty to one hundred seconds.

Amount of Gas Required.—The amount of gas usually required to produce satisfactory anæsthesia in an adult is from five to six gallons. Of this quantity, according to the careful measurements of Dr. Evans of Paris, there remains in solution in the blood at the time of full anæsthesia an average of three quarts. M. Paul Bert, a later observer, finds that one hundred volumes of blood hold in solution forty-five volumes of gas when anæsthesia is complete.

Expiratory Products.—The products of the expiratory movements which take place during the administration of the gas are found to consist of the residuum of atmospheric air remaining in the lungs at the beginning of the process, *unchanged* nitrous oxide, watery vapor, and carbonic acid gas. The amount of the latter gas exhaled is often almost 50 per cent. less than during normal respiration—a result doubtless due to the partial suspension of the process of combustion through the insufficient supply of oxygen to the tissues.

MM. Jolyet and Blanche report some carefully conducted experiments made with a view to ascertaining the changes produced in the gases held in solution in the blood by the inhalation of nitrous oxide.[2] A dog after breathing pure air was found to have in one hundred cubic centimeters of blood the following percentage of gases:

Carbonic acid	48.8 per cent.
Oxygen	21 " "
Nitrogen	2 " "

The dog was then made to breathe within a bag a gaseous mixture consisting of—

Nitrous oxide	62 per cent.
Oxygen	24 " "
Nitrogen	17 " "

In seven minutes and thirty seconds the animal inhaled 50 liters of this mixture, and during all that time remained sensible to the touching of

[1] See method of M. Paul Bert, p. 170.
[2] *Archives de Physiologie*, tome cinquième, 1873.

the eye and pinching of the toes. The analysis of the gases in the blood then made gave for 100 cubic centimeters of arterial blood, quite red—

Carbonic acid gas	46	per	cent.
Oxygen	19.7	"	"
Nitrous oxide	29	"	"
Nitrogen	0.3	"	"

The same animal, having been allowed to rest during half an hour, was made to breathe pure nitrous oxide during one minute forty-five seconds: the animal was incommoded in his respiration, but retained sensibility. An analysis of the gases in the blackened arterial blood was then made, and it was found to contain—

Carbonic acid gas	37	per	cent.
Oxygen	5.2	"	"
Nitrous oxide	28.1	"	"
Nitrogen	0.7	"	"

A second dog, breathing in the same manner within a bag of nitrous oxide, was found insensible to pinching and to contact with the conjunctiva after three minutes. The analysis of the gases of the blood then made gave for 100 cubic centimeters of very black arterial blood—

Carbonic acid gas	36.6	per	cent.
Oxygen	3.3	"	"
Nitrous oxide	34.6	"	"

A third dog, breathing within a bag of nitrous oxide, was still a little sensible at the third minute, and was found completely insensible to the electrization of the sciatic nerve after four minutes. The analysis of the arterial blood, very black, gave—

Carbonic acid gas	34	per	cent.
Oxygen	0.05	"	"
Nitrous oxide	37	"	"

Return to Consciousness.—The recovery of the patient from the effect of nitrous oxide is usually very rapid and unattended by unpleasant symptoms. In females of a nervous temperament hysterical manifestations are occasionally developed, but these usually disappear as the gas becomes fully eliminated from the circulation, and nervous tremors, slight convulsions, moans, or piercing shrieks need excite no particular alarm; indeed, the louder the outcry the more assured is the safety of the patient, as it indicates a vigor of lung-power and a rapidity of respiratory changes in the highest degree salutary and assuring. The restoration to consciousness is attended by subjective sensations varying greatly in character: as a rule, these sensations are not very agreeable; often they are intensely painful, especially when the operation has been severe or unduly prolonged; but not infrequently the patient awakes as from a delightful dream, having known neither pain nor discomfort throughout the entire process. The recovery of consciousness is usually attended by the same dizziness and ringing in the ears which preceded its loss; the tinnitus aurium sometimes becomes a crescendo movement ending in a deafening roar like the rush of an approaching express-train. As the

blood becomes again oxygenated the normal appearance of the patient is restored, and usually all the functions resume their wonted activity.

Resuscitatory Measures.—Signs of danger, when they occur, are usually connected with the respiratory function: intensified lividity of the face or great and sudden pallor, deepening stertor, cessation of respiration,—all are grave symptoms, and demand prompt remedial measures. In dental practice, to which the use of nitrous oxide is so largely confined, it will be found that the most prompt and generally efficacious resuscitatory measure is to draw the patient directly forward from the chair, supporting him in a nearly horizontal position face downward, thus favoring the removal of any obstruction caused by the tongue: the operator may at the same time stimulate the respiratory reflexes by thrusting the finger into the fauces. In a vast majority of cases these simple measures will avail, but should evidences of respiratory or cardiac arrest continue, such symptoms must be met by prompt recourse to those other methods for the resuscitation of patients thus perilously circumstanced already fully described in that portion of this paper devoted to the consideration of the properties and uses of sulphuric ether.

NATURE OF NITROUS OXIDE NARCOSIS.—The most superficial observer of the physiological effects of undiluted nitrous oxide cannot fail to note the fact that a more or less complete asphyxia is one of the leading symptoms produced. Many have over-hastily arrived at the conclusion that asphyxia pure and simple is the essential element, and, indeed, the sole factor in anæsthesia with this agent. This conclusion, however, is not well founded, as the simple asphyxia produced by mechanical means or by the inhalation of inert gases, such as hydrogen and nitrogen, differs greatly from that incident to narcosis from nitrous oxide.

Even more erroneous is the view, once urged with considerable insistence by various writers upon the subject, that anæsthesia with nitrous oxide is a condition of hyperoxygenation resulting from the decomposition of the nitrous oxide in the circulation. The fallacy of this position is manifest from the fact that a much higher temperature than that at which animal life is possible is necessary to effect any rapid decomposition of the gas, and that nitrous oxide when inhaled comes off from the lungs unchanged.

The experiments of MM. F. Jolyet and T. Blanche show that the germination of seeds and the growth of plants are arrested in pure nitrous oxide, and that the gas is not able to support respiration in animal any more than in vegetable life. The manner of conducting these researches is thus described by the experimenters:[1]

"We placed under bell-glasses containing nitrous oxide, chemically pure, grains of barley and water-cress in contact with moist filtering-paper. We have demonstrated that after nine days in one case and fifteen in another the seeds did not present the slightest indication of germination, while other barley and water-cress seeds arranged in the same manner, but under a bell-glass filled with atmospheric air, had entered upon full germination by the second or third day.

[1] *Comptes rendus*, séance du Lundi, Juillet, 1873, pp. 59-61.

"The seeds placed in nitrous oxide germinated in their turn when a few centimeters of oxygen were passed under the bell-glasses.

"The same results were obtained with seeds in course of development: the development was arrested in an atmosphere of nitrous oxide, and resumed when oxygen was placed beneath the bell-glass. . . .

"Birds" (in nitrous oxide) "die in thirty seconds; the mammifers (rabbits and dogs), in from three to four and a half minutes. At death the blood is black in the vessels; the autopsy presents the ordinary signs of asphyxia by inert gases, nitrogen and hydrogen.

"We have made dogs breathe a mixture of nitrous oxide and oxygen in the relative proportions of atmospheric air during from twenty to thirty minutes without having been able to discover at any time any appreciable diminution of sensibility: the sciatic nerve, excited by a feeble galvanic current, has always produced signs of acute pain.

"These experiments are sufficient to show that nitrous oxide gas is not a true anæsthetic agent, and that it produces insensibility only by causing asphyxia."

This conclusion, based upon insufficient data, more recent investigation has completely nullified, and no fact is more clearly ascertained than that nitrous oxide, like chloroform and ether, does possess specific anæsthetic power, the asphyxia being merely incidental and entirely dependent upon the manner in which the gas is administered. Like the vapor of the liquid anæsthetics, nitrous oxide is simply held in solution in the blood, and from thence exercises its peculiar influence upon the nervous system.

What, in its final analysis, the nature of this influence really is, is still undetermined. Claude Bernard, C. Binz, and Heinrich Ranke have each advanced the doctrine that anæsthetics in general produce in nervous protoplasm molecular changes closely allied to, if not identical with, coagulation ("semi-coagulation of the intimate constituents of the nervous-cells"—Bernard), this resulting in temporary arrest of functional power. As this arrest is only transient, the resolution and revitalization of the coagulated albumen must be assumed.

That this sequence of changes is possible would seem to be indicated by the fact that the albumen of serum coagulated by alcohol redissolves if quickly placed in water, but if allowed to remain for some time exposed to the action of the alcohol, it becomes permanent and insoluble (Brunton).

Whether coagulation of protoplasm be the causative agent or not, there is no doubt that arrest of molecular movement in those centres in which nervous force is generated is a determining condition of narcosis, and that such arrest is the result of the interference of the narcotic agent with that tissue oxidation upon which all vital phenomena are dependent. Whether this interference is effected through the mechanism of coagulation is still an open question. The theory of Lyman is that the narcotic "effects no new combinations or decompositions. Among the molecules it merely plays the part of a cloud between the sun and the earth, hindering the energies of the one from acting upon the susceptible matter of the other."

Experiments of Paul Bert.—Much light has been thrown upon

the true nature of nitrous oxide narcosis by the experiments of the late Prof. Paul Bert, who by administering under increased atmospheric pressure a mixture of oxygen and nitrous oxide succeeded in producing a prolonged and profound anæsthesia, while at the same time maintaining the normal proportion of oxygen in the blood. This mixture of oxygen and nitrous oxide had repeatedly been tested before Paul Bert's experiments, but with unsatisfactory results, because under normal pressure even a small amount of oxygen was found to dilute the nitrous oxide—that is, widen the distance between its molecules too much to permit of its full physiological effects being produced.

Laws of Dosage.—In giving any drug with a view to the full development of its physiological action the laws of dosage must be observed: a given amount, ascertained by experiment, must be administered in a given time. If the amount be diminished, either absolutely, or relatively as to time by unduly extending the period occupied in its administration, diminution in potency of effect must result.

In the exhibition of remedies hypodermically or by the stomach the laws of dosage are, as a rule, readily ascertained and observed, but in the administration by the lungs of an aëriform substance, such as nitrous oxide, the volatile nature of the agent and the physical obstacles to its retention in contact with absorptive surfaces complicate the problem: a much larger amount must be inhaled than can be absorbed, because repeated respiratory acts are necessary in order to bring fresh supplies of gas in contact with those finer ramifications of the air-passages from which it diffuses into the blood with the greatest rapidity; a large percentage of the gas inhaled fails to reach these surfaces, but remains in the larger bronchial tubes, where absorption is both absolutely and, as to volume, relatively slower, and whence much of it is driven out and lost at each expiration.

Practical experience has shown that in order to develop the full physiological effects of nitrous oxide at normal pressure, from five to seven gallons of pure gas must enter the lungs in about a minute of time. To materially diminish the amount of the gas, or to subdivide it into several doses with a considerable interval of time between each dose, would alike defeat the purpose of its administration, just as the dividing the physiological dose of morphia, one-sixth of a grain, into one hundred and sixty-eight parts, and giving one part every hour for a week, would be an utterly futile procedure were pronounced physiological effects desired, the reason of failure in each case being that a sufficient number of the molecules of the agent employed have not been brought in contact with absorptive surfaces within a sufficiently limited period of time, the result being that the molecules first absorbed are eliminated from the system before additional molecules can come to their aid, defeat in detail being the necessary consequence.

This result has been found to follow all dilutions of nitrous oxide at normal atmospheric pressure; but if the molecules of nitrous oxide, diluted—that is, driven more widely asunder—by the interposition of molecules of oxygen, can again be driven together, so that they and the oxygen shall occupy only the bulk filled by the nitrous oxide alone before the addition of the oxygen, then when inhaled the same number

of nitrous oxide molecules will enter the lungs at each inspiration as before dilution, and room still be left for the molecules of oxygen.

Compression of Nitrous Oxide.—The compression of the gas or gases is of course readily accomplished, but in order to secure successful anæsthetic results the patient also must be placed under the same atmospheric pressure as that at which the anæsthetic mixture is held, so that the pressure of the gases as they enter the lungs may be exactly counterbalanced by the pressure of the air upon the walls of the chest. This result, except under peculiar conditions, it is impossible to obtain in the open air. Dr. Fontaine[1] has pointed out that in very deep mines atmospheric pressure is so much greater than at the surface of the globe, as is notably the case in two mines in England, in which the barometer marks 90 and 92 centimeters respectively (76 normal), that, should a surgical operation in those depths become necessary, nitrous oxide diluted with a limited amount of oxygen might be employed without any special apparatus; but at ordinary levels some such appliances as those employed by Prof. Bert are absolutely necessary. M. Bert's invention was first publicly announced in a communication to the French Academy,[2] in which he says:

"Nitrous oxide, the anæsthetic properties of which were discovered by Humphry Davy at the end of the last century, is to-day employed by a very large number of practitioners to obtain insensibility during the extraction of teeth. But that insensibility cannot be prolonged, for the reason that at the moment in which it is complete signs of asphyxia appear, which speedily become formidable. American surgeons have not yet succeeded in performing prolonged operations under nitrous oxide, except by producing brief anæsthetic sleeps frequently repeated, but separated by periods of sensibility.

"This disability is due to the fact that anæsthesia with this agent cannot be produced unless the patient is made to breathe pure nitrous oxide without any admixture with air, the result being that asphyxia keeps equal pace with anæsthesia.

"I have attempted to remedy this serious disadvantage, and have succeeded in obtaining an anæsthesia indefinitely prolonged, and at the same time absolutely free from all danger of asphyxia.

"The fact that nitrous oxide must be administered pure signifies that in order that a sufficient quantity may penetrate the organism the tension of the gas should be equal to one atmosphere. Under normal atmospheric pressure it is necessary in order to secure this result that the gas should be inhaled in the proportion of one hundred volumes in one hundred. But if we suppose the patient placed in an apparatus where the pressure may be raised to two atmospheres, it would be possible to give the gas at the desired tension by making him inhale a mixture consisting of fifty parts nitrous oxide and fifty parts of atmospheric air; thus anæsthesia should be obtained while at the same time maintaining the normal quantity of oxygen in the blood, and so conserving the normal conditions of respiration.

"This result has been obtained, but it should be stated that as yet I have experimented only upon animals. These experiments have been performed as follows: I enter the cylinder, and, increasing the atmospheric pressure

[1] *L'Union Médicale*, Sept. 18, 1879.

[2] *Comptes rendus des Séances de l'Académie des Sciences*, séances du Lundi, 11 Novembre, 1878.

one-fifth above the normal, there cause a dog to inhale a mixture consisting of five-sixths nitrous oxide and one-fifth oxygen gas—a mixture in which it will be seen that the tension of the so-called laughing gas is precisely equal to one atmosphere. Under these conditions the animal is in one or two minutes, after a very brief period of excitement, completely anæsthetized; the cornea or conjunctiva may be touched without making the eye wink; the pupil is dilated; a nerve of sensation may be exposed and pinched, a limb may be amputated, without causing the slightest movement. The muscular relaxation is truly extraordinary, and were it not that the respiratory movements continue with perfect regularity, the animal would appear stricken with death. This condition may continue half an hour or an hour without any change. During all this time the blood preserves its red color and its normal amount of oxygen, the heart pulsates with its usual force and regularity, and the temperature continues unchanged. During this entire period the excitation of a centripetal nerve produces in the respiratory and circulatory functions all the usual reflex manifestations; all the phenomena of the so-called vegetative life remain unchanged, while those peculiar to animal life are absolutely abolished.

"When, after whatever period of time, the bag containing the mixture of gases is removed, the animal at the third or fourth respiration of pure air will immediately recover sensation and intelligence, as proved by his desire to bite, which sometimes he manifests immediately. When unloosed he hurries away, walking freely and recovering at once his gayety and vivacity.

"The rapid return to the normal condition, so different from that which is observed with chloroform, is due to the fact that nitrous oxide does not, like chloroform, enter into chemical combinations in the organism, but is simply dissolved in the blood. As soon as the gas is no longer contained in the air inhaled it rapidly escapes through the lungs, as analyses of the gases in the blood have shown me.

"The innocuousness of the action of nitrous oxide is shown from the recital of these experiences. On the one hand, in fact, the anæsthesia, in striking down the sensibility of the spinal cord, respects the reflexes of organic life, the suppression of which, readily effected by chloroform, can alone put life in jeopardy; on the other hand, the immediate return to the normal state when the patient is again brought into free air makes the operator at all times master of the situation.

"This freedom from danger is shown not less clearly from the infinitely small number of accidents which have followed the inhalations (numbered by hundreds of thousands) effected at the hands of dentists, often with a total disregard of prudence and a total absence of competency, and under conditions in which asphyxia augments the dangers, if any exist, of anæsthesia with this agent.

"I am therefore now authorized by the result of my experiments made upon animals to earnestly recommend to surgeons the employment of nitrous oxide under pressure, with a view to obtaining an anæsthesia of long duration. I can assure them that they will obtain, in proportioning as I have indicated the barometric pressure and the centesimal composition of the mélange, so as to have, for the nitrous oxide, the tension of one atmosphere, and for the oxygen at least the normal tension of the air, an insensibility and a muscular relaxation as complete as they will desire, followed by an immediate return of sensation and condition of general well-being perfect in character."

A few months subsequently M. Bert addressed to the Academy a com-

munication in which he announced the successful employment of his method upon the human subject, and gave the following account of the first operation performed:[1]

"Two surgeons of the hospital of Paris have responded to the appeal which I addressed to surgical practitioners, and I now give to the Academy an account of the operations which they have performed after the new method. As a typical case I will first describe the first operation, which was performed by M. Labbé.

"The operation required was the extirpation of an ingrowing nail, with removal of the matrix. The patient was a young girl twenty years of age, very timid and nervous. We entered the large sheet-iron chamber in the establishment of Dr. Daupley, where the pressure of the air was in a few minutes augmented by $0^{m}.17$ (total pressure, $0^{m}.92$). The patient placed herself at full length upon a mattress, and M. Préterre applied to her mouth and nose the valved mouthpiece which he is accustomed to employ for the inhalation of pure nitrous oxide; then the sack with which it communicates was filled with a mixture containing eighty-five parts of nitrous oxide and fifteen parts of oxygen. I held one of the arms of the patient and found the pulse quite rapid, when suddenly, without having been warned by any change in the pulse, the respiration, or the color of the skin, without any rigidity, agitation, or excitation having been produced, in from ten to fifteen seconds after the first inspiration of the anæsthetic gas, I felt the arm become completely enfeebled; insensibility and muscular relaxation were obtained; even the cornea could be touched with impunity. The operation began immediately, and the dressing of the wound followed without a single movement of the patient, who remained in a calm sleep; the pulse had returned to the normal rate. At the end of about four minutes, at the moment when M. Labbé had finished dressing the wound, slight muscular contraction in an arm, and then in a leg, was perceived. The operation having been completed, the mouthpiece was removed and the contractions immediately ceased. During thirty seconds the patient continued to sleep; then, some one having tapped her upon the shoulder, she awoke, regarded us with an air of astonishment, sat up, and suddenly cried that her foot was hurting her; indeed, the pain was sufficient to cause her during a few seconds to shed tears. Being interrogated, she declared that she felt perfectly well and was very hungry, as, owing to fright, she had neither breakfasted in the morning nor dined in the evening. She declared further that she had felt nothing, dreamed nothing, but she recalled that at the first inhalations of the mixture she experienced a feeling of great well-being, that she appeared to be mounting to heaven, and that she 'saw the blue sky with the stars.' This being said, she arose and went on foot to the vehicle which was to convey her to the hospital; but on the way she complained so much of hunger that it was necessary to stop in order to obtain for her something to eat. No ill consequences of any kind have resulted from the operation.

"I have given in some detail the history of this first operation, because it exhibits very clearly the great difference between the action of nitrous oxide and that of ether or of chloroform, especially as regards the instantaneousness of the sleep and the awakening. But the operations performed at the establishment of Dr. Fontaine—operations which are now sixteen in number—have been much more important, and as a consequence much more conclusive. They comprise three amputations of the breast, four

[1] *Comptes rendus*, séance du Lundi, 21 Juillet, 1879.

operations upon the bones, six extirpations of different varieties of tumors, a resection of the infraorbital nerve, and two reductions of shoulder dislocation of three or four days' standing. The duration of the anæsthesia has varied from four to twenty-six minutes. Insensibility has been complete during a period varying from fifteen seconds to two minutes. During one of the operations a slight accident to the apparatus permitted to the patient one respiration of the exterior air: she immediately began to speak, but without any manifestation of pain; at the first renewed inspiration of the anæsthetic mixture speech was arrested, and upon awakening she recalled nothing of what had happened.

"The pulse and respiration are sometimes accelerated at the beginning of the inhalation, and it is not yet possible to determine to what extent these phenomena are due to the action of the gas. As soon as the patient becomes insensible the normal rate is restored. In a great majority of cases the patients issue from the apparatus without complaint of any disagreeable sensations of any kind: when the operation has not been grave they depart on foot, and frequently ask for something to eat. In three cases nausea has been complained of; but as these cases were precisely coincident with the employment of hard-rubber mouthpieces and gas-bags made of new rubber, it is impossible to determine whether the nausea should or should not be attributed to the nitrous oxide: my own opinion is that it should not.

"A symptom more frequent, and which might appear sufficiently grave, is the appearance of muscular contractions in the limbs. I am sure that they are due to the fact that the nitrous oxide is not under a sufficient tension. In order to quiet the spasmodic action, it is only necessary to make the pressure in the pneumatic chamber from $0^m.02$ to $0^m.03$ greater; and this can be effected almost instantaneously. The pressure employed has oscillated between $0^m.15$ and $0^m.22$ above the normal. . . . . Thus the employment of compressed air permits with the greatest facility the modification of dosage in pneumatic therapeutics. Nothing would be more difficult than to change the proportions of a mixture of gases: nothing is more simple than to vary the tension, and as a consequence the physiological dose.

"To sum up: Nitrous oxide enters the domain of major surgery. The previsions of my communication of November 11 have been realized. It has shown its superiority over the hydrocarbon and chlorine compounds—1st, by the absence of that period of initial excitation often so distressing and at times even dangerous; 2d, by the security it affords the surgeon, who, assured that the dosage of the anæsthetic agent cannot change during the operation, knows, as a consequence, that the patient has nothing to fear; 3d, by the return, almost instantaneous, even after twenty-six minutes of anæsthesia, to complete sensibility, so that it would be quite possible, were it desired, to awaken the patient at any time during the operation and immediately put him to sleep again; 4th, by the almost invariable absence of malaise, nausea, and vomiting, so frequent, so exhausting, and sometimes so persistent, in cases where the patient has been placed under the influence of chloroform or ether; 5th, by its remarkable freedom from danger, the reasons for which have already been explained in my first communication, and have since then been confirmed by experiments upon the human subject.

"I do not believe that the mechanical difficulties attending this method —difficulties which have been greatly diminished by the introduction of a movable pneumatic chamber by Dr. Fontaine—will deter surgeons from its

use; but it is my duty to-day to thank Drs. Labbé and Péan, whose bold initiative, justified by the result of my previous experiments, has allowed nitrous oxide to pass from the laboratory of the physiologist to the operating-room of the surgeon."

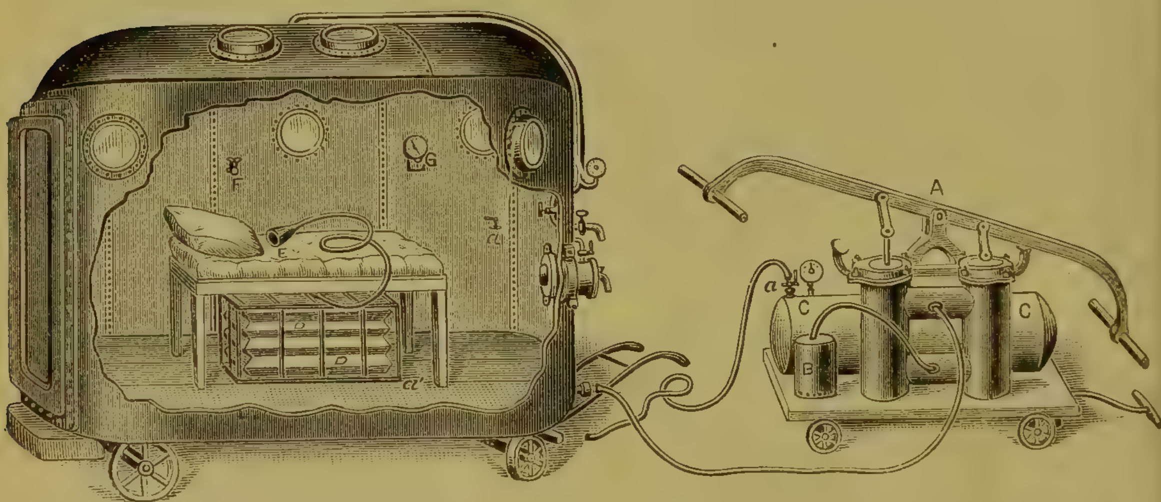
The pneumatic chamber above mentioned is thus described by Dr. Fontaine:[1] (Fig. 27.)

"This apparatus, mounted upon a truck, is painted white on the inside. It is lighted by ten portholes, of which the four upper ones shine directly upon the operating-table. The width of the chamber is two meters (a little over six feet and a half), its length three meters and a half (about eleven feet and a half), its height two meters and sixty-five hundredths (a little more than eight feet and a half). It will comfortably accommodate ten or twelve persons.

"The receiver in which M. Péan has operated during the last three months, and into which he took with him five or six assistants, had not one-third the available space that has the apparatus just described. The pressure can be regulated at will, either from the interior or the exterior. In either case a metallic manometer serves as a guide.

"By the side of the pneumatic chamber, upon a little truck, are placed —1st, a double-cylindered hand-pump, A, with liquid piston, capable of

FIG. 27.



giving from four hundred to six hundred liters of air per minute. 2d, a refrigerator, B, placed in the path of the air from the pump, in order to prevent the temperature of the pneumatic chamber from rising more than one or two degrees above that of the surrounding air. During the winter the refrigerator can be replaced by a heating apparatus consisting of a hot-water bath surrounding a coiled pipe, through which the air may pass. 3d, an iron receiver, C, containing three hundred and fifty liters of the anæsthetic gaseous mixture at a pressure of ten atmospheres (about three and a half cubic meters at the ordinary atmospheric pressure).

"Upon the inside of the pneumatic chamber are seen two keys, *a* and F, of which the first operates a stopcock which communicates with the

[1] "Emploi chirurgical de l'Air comprimé." *L'Union Médicale*, Sept. 18, 1879, p. 445. See also *De l'Anesthésie par le Protoxyde d'Azote d'après la méthode de M. le Professeur Paul Bert*, par Raphaël Blanchard, Docteur en médecine, etc.

receiver, C, containing the anæsthetic mixture under pressure, and with the gas-bag, D, placed under the operating-table. When this bag is nearly empty it can be filled by connecting the stopcocks with the rubber tubing which forms the supply-pipe. The second key, F, belongs to a whistle used to signal to those who operate the pump.

"At the letter E in the figure is seen the facepiece of the inhaling apparatus."

PAUL BERT'S METHOD IN DENTISTRY.—Dr. E. Goetz, in a paper read before the Medical Society of Geneva, December 5, 1883, states that two dentists in that city, M. Roussy and M. Guillermin, have placed in their offices apparatus for giving nitrous oxide gas after Paul Bert's method. The pneumatic chamber used by the former has a capacity of fifty-eight hundred liters and will hold four persons very comfortably.

"It contains an arm-chair and a table, under which is placed a rubber bag capable of holding one hundred and fifty liters of the mixture of nitrous oxide and oxygen—a quantity sufficient to maintain anæsthesia for about fifteen minutes. All the instruments, as well as the water, towels, and napkins necessary for the operation, are put into the pneumatic chamber: if by chance the operator has forgotten anything or has need of another instrument, he can readily obtain it by means of an opening with double doors through which anything he may wish can be passed without changing the tension of the condensed air.

"The compression of the air is effected by means of an hydraulic motor of two horse-power placed in the basement. This puts in action an air-pump, suction and forcing, which conveys the air into the pneumatic chamber by means of perfectly-jointed metallic pipes. In order that time may not be lost in waiting for a sufficient tension in the chamber, M. Roussy has placed near by a reservoir of sheet iron in which eighteen hundred liters of compressed air may be stored at a pressure of one atmosphere and a half. During each anæsthetic *séance* a mechanician should be placed near the apparatus to obey the electric signals transmitted by the operator.

"To secure a pressure of twenty-five centimeters with the pump alone requires nine minutes; seven minutes are sufficient when the air has been compressed in advance in the reservoir just spoken of.

"The first twenty experiments were made with the mixture of gases recommended by Paul Bert—fifteen parts of oxygen to eighty-five parts of nitrous oxide, with a pressure of from twenty-five to twenty-eight centimeters. For later operations the proportion has been twelve of oxygen to eighty-eight of nitrous oxide: anæsthesia with this combination has appeared to be produced more rapidly and to be of longer duration.

"With this explanation it is easy to comprehend the function of the apparatus. The patient and the operator, accompanied by one or two assistants, enter the pneumatic chamber: the door is closed and all communication with the outer air is arrested. The cock communicating with the reservoir is opened; immediately the compressed air enters the chamber, causing the manometer to rapidly rise ten centimeters. Then the signal is given to the mechanician to put the pump in movement; each stroke of the piston is distinctly heard in the chamber. The first impression experienced is not very agreeable: one feels a painful sensation in the ears, produced by the inequality of tension between the middle ear and the external wall of the tympanum. To overcome this difficulty, maintained

by a slight mucous obstruction of the Eustachian tube, all that is necessary is to go through the movements of deglutition several times: the vacuum produced in the pharynx by these movements draws out the air retained in the drum of the ear and re-establishes the permeability of the tube. If the obstruction resists these means, all that is necessary is to turn the stopcock, placing the chamber in communication with the exterior air: the tension will be lowered two or three centimeters and the normal condition of things will be restored. This is the sole inconvenience which we have experienced, and even that is not of invariable occurrence. In one case, however, the pain felt by one of the assistants, a physician of our city, was such that it was necessary to momentarily suspend the pressure and increase it only very slowly. This is the only case we have observed, and I have not found other examples of a like nature in the published reports of MM. Blanchard and Martin.

"I have, in all my observations, counted the pulse and the respiration before the compression of the air and at the moment in which it attained its maximum: I have not found any notable difference, but usually a little acceleration of the pulse. It need hardly be said that these observations were made either upon myself or an assistant, for the patient, agitated by the thought of the operation to which he is about to submit, presents almost always an acceleration of the pulse, which increases as the moment approaches.

"At the end of nine or ten minutes the tension in the pneumatic chamber is sufficient: the manometer marks twenty-five centimeters and the barometer one hundred centimeters or a little more. The administration of the anæsthetic is then begun: the mask is applied to the face of the patient and the communication with the sack containing the anæsthetic mixture is opened. After ten or fifteen inspirations, often after only six or eight, anæsthesia is complete, without excitation, without change of color either in the skin or mucous membrane, and without modification in the respiratory rhythm. The limbs become relaxed, the conjunctiva is insensible, the pupil slightly dilated. The muscles of the jaw alone retain contractile power, and this even in a somewhat exaggerated form, so that it is well to place a prop in the mouth before the commencement of inhalation. When the anæsthesia is deemed sufficient the operation may be performed without any very great haste; indeed, with the method of Paul Bert applied to the extraction of the teeth, in which it is necessary to remove the mask, the time afforded the operator is very much longer than by the ordinary method without compression: we have always obtained, and with moderate pressure, a minute or a minute and a quarter of absolute anæsthesia, often followed by a period of analgesia sufficiently perfect to prevent suffering even though the patient is conscious that his teeth are being extracted. In order to obtain a more prolonged anæsthesia it is only necessary to give the patient a little more of the anæsthetic or to increase the atmospheric pressure a few centimeters, which can be done without the slightest inconvenience.

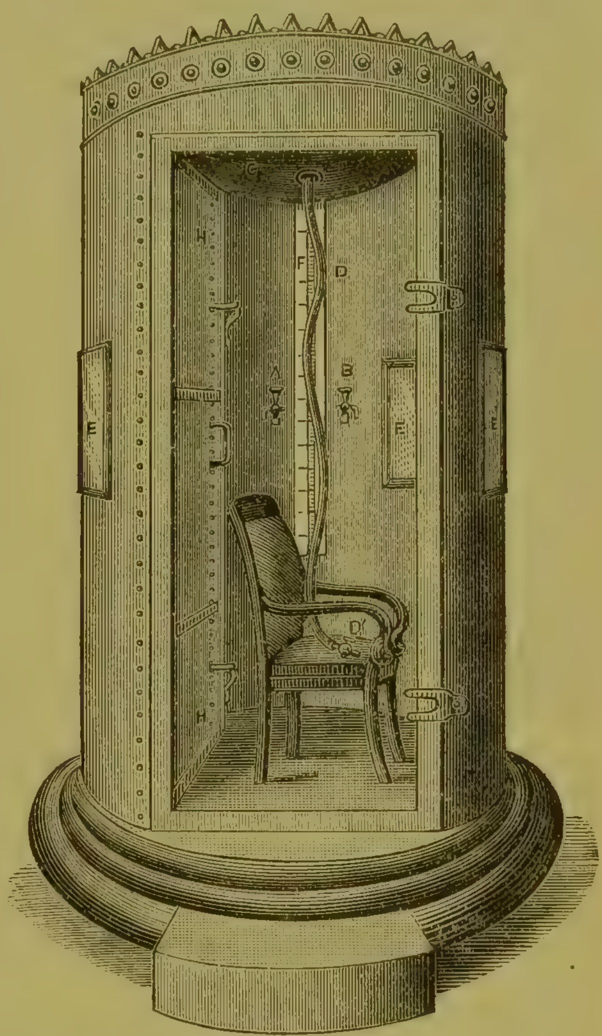
"The operation being terminated, the patient recovers consciousness almost immediately, and has no subsequent feeling of malaise.

"The stopcock which permits the escape of the compressed air is then opened and little by little the tension becomes normal."

Fig. 28 represents the pneumatic chamber employed by M. Guillermin of Geneva, who gives the following description of its mechanism:

"It is sufficient to state that the apparatus is provided with a pump to compress the atmospheric air into a large special reservoir. This reservoir communicates with the key A (Fig. 28) of the pneumatic chamber by a pipe. There is also connected with the apparatus a pump for the compression of the mixture of nitrous oxide and oxygen into a smaller reservoir, which is in communication with the sac CC. These need not here be further described. We will enter more into detail concerning the principal apparatus, the pneumatic chamber:

Fig. 28.



"It is constructed absolutely upon the same principle as that which was used in operations in major surgery in Paris: it differs only in that its dimensions are smaller and in some interior arrangements designed to make easier its operation. It is a round chamber made of steel plate, measuring 2.20 meters (a little over six feet) in height by 1.20 meters (a little more than three feet) in diameter. It is closed by a door, HH, also of steel plate, opening from without to within, and the edges of which have upon their entire length a band of rubber, assuring the hermetical closure of the cabinet. Articulated bolts fixed to the door enter into grooves welded to the walls of the chamber, and are firmly screwed by a nut-wrench. The light is introduced by four portholes or windows, E, E, E. The sack, CC, contains the mixed gases, the proportions of which are calculated by the means of a 'Limousin' reckoner, which gives even the deciliters. The sack has two openings—a large one for the gas to enter, and the other smaller, from which hangs the pipe D, terminated by the inhaler, D′, that is seen lying on the operating-chair. The operator manages the apparatus easily. The door closed and the patient seated, the stopcock A (entrance of the compressed air) is opened; the pressure of the air is produced at once; the column of mercury is seen to mount in the barometer, F. The inhaler, D′, is placed over the face of the patient, who rapidly passes into a calm and profound sleep. When the operation is done the stopcock, B, is opened, and in two or three minutes the reduction of pressure is complete and the column of mercury resumes its normal state. The door is opened from the outside, and the patient, who is well immediately and without malaise of any kind, is able to go out: all is finished."

Concerning the utility of the apparatus, M. Guillermin states that—

"Operations upon parts of the face covered by the inhaler are also very easily performed by the method of Paul Bert, by supersaturating the patient (which can be done with absolute harmlessness). A large quantity of the gas accumulates in the blood, and while the gas escapes by the lungs the insensibility remains several minutes after the inhaler is removed. Many consecutive extractions of teeth can be made.

"Dr. Péan and other surgeons are able to use this same principle to perform different operations upon the lips (ablation of cancroids and epitheliomas), resection of the superior maxillary nerve, etc. This *supersaturation* cannot be effected with pure nitrous oxide without imminent danger of asphyxia."[1]

Dr. Goetz states that in addition to the pneumatic apparatus of M. Fontaine in Paris, previously described, and those of MM. Roussy and Guillermin in Geneva, a pneumatic chamber has been constructed for M. Martin at Lyons, in which Prof. Gayet has performed an iridectomy and an enucleation of the eye, and that Prof. Deroubaix of Brussels has placed a complete apparatus in St. John's Hospital, in which he has applied the method of Paul Bert with excellent results.

Nitrous Oxide and Oxygen at Normal Pressure.—Subsequent to the introduction of this process M. Bert demonstrated that prolonged anæsthesia may be safely obtained with nitrous oxide at normal pressure by giving first the gas in the pure form, and then a mixture of nitrous oxide and oxygen: thus the blood is first saturated with the anæsthetic gas and then oxygenated by the oxygen of the mixture, the nitrous oxide the latter contains serving at the same time to keep up, to a certain extent, the anæsthetic influence. When this ceases to be sufficiently profound the pure gas is again administered, followed in its turn by the mixture.

This procedure is not absolutely novel, as American specialists have frequently succeeded in keeping up anæsthetic influence for several minutes by giving alternate doses of pure nitrous oxide and atmospheric air. The oxygen mixture of M. Bert is, however, a decided improvement; but for obvious reasons the usefulness of this plan must in a great measure be restricted to operations other than in the mouth.

Nitrous Oxide and Oxygen in Obstetrical Practice.—Dr. Macan, in a paper read before the Obstetrical Society of Dublin, gave an account of the use of a combination of nitrous oxide and oxygen in labor, and "described the latest modification introduced by Dr. Kilkowitosch of St. Petersburg, who employed the gas mixed with 20 per cent. of oxygen. The quantity of this mixture inhaled in each case varied from two to ten cubic feet, but its use might be continued for an unlimited time, as it was capable of supporting life like atmospheric air, and was quite free from danger, the patient, though quite anæsthetic, never losing consciousness; neither did nausea, vomiting, or headache result from its employment. Again, the amount of intra-uterine pressure, as tested by the dynamometer, exerted during the pains was not in the least diminished, even when complete anæsthesia was pro-

[1] "Emploi du Protoxyde d'Azote sous Pression, par M. Guillermin, Médecin-dentiste à Genève," *Gazette Odontologique*, Avril, 1881.

duced, whilst chloroform and ether were well known to cause marked diminution in the frequency and fulness of uterine and abdominal contractions."[1]

SECONDARY EFFECTS RESULTING FROM NITROUS OXIDE NARCOSIS.—These effects are usually of trifling importance. Headache is not infrequent, and occasionally there is slight nervous prostration, continuing for some hours or even days. It is hardly to be supposed, however, that so grave an interference with the functional power of important nervous tracts is invariably attended by absolute immunity from injurious results more or less serious in character.

Probably few practitioners of experience have not heard from or of persons that they have never been well since taking the gas. Concerning this matter, Prof. Darby writes:

"I have long been of the opinion that nitrous oxide gas is not as harmless as it is generally believed to be. I never see a person under its influence that I do not ask myself the question, Can any agent that produces the effect and appearance which this does be safe or be taken without danger to the general health? Given as it is by careless and often inexperienced men, the gas, I doubt not, being frequently impure, the anæsthetic must have a degree of safety, otherwise the deaths would be numerous, but whether all who take it return to perfect health I must question.

"One lady said to me that she attributed all her ill health to this agent, she having enjoyed perfect health until she took the gas for the purpose of having teeth extracted.

"Another case has been reported to me of a lady who has 'never had a well day' since, three years before, she had taken nitrous oxide. Indeed, several persons have remarked to me that they have never been well since taking the gas.

"While these cases do not positively prove anything, they are nevertheless important factors in helping us to form an opinion as to the perfect safety of the agent."

The late Prof. George T. Barker held very pronounced views as to the harmfulness of nitrous oxide as an anæsthetic agent, this unfavorable opinion being largely based upon his own unfortunate personal experience, he having had a severe attack of pneumonia the day following his inhalation of the gas, from the secondary effects of which attack he never fully recovered.

While, in common with Prof. Darby and many others, the writer has frequently heard statements as to the permanently injurious results which in individual instances have followed the inhalation of nitrous oxide, it has not been easy to secure satisfactory data concerning such cases. The statements themselves have been vague, and very often the symptoms complained of obscure. In any case, the difficulty of establishing a true causative relation between the anæsthetic agent and the disease is sufficiently obvious: in the following three cases, however, indications of pathological effects followed so promptly the inhalation of the anæsthetic as to afford ample reason for the presumption that such a relation really existed. For details concerning the first of these

[1] *British Med. Journ.*, Feb. 4, 1882.

cases the writer is indebted to Prof. C. N. Peirce and to Drs. R. J. Rudderow and James J. Levick.

The first case is that of the late Dr. K——, a practising physician of Philadelphia, concerning whom Prof. Peirce writes:

"I went with him to Dr. —— to have some roots removed under the influence of gas. He was then a man weighing two hundred pounds, was in good health, but was readily fatigued by violent exercise; indeed, he would not attempt to walk rapidly. The roots were all extracted with one administration of gas and at the immediate time without any unusual circumstances. From the office of Dr. —— he went to his place of residence, distant but a few blocks, where he remained for some hours, feeling very much prostrated, his face having an ash color and his circulation not resuming its normal condition for some hours.

"Within a few days sugar was discovered in his urine—my own recollection is that it was within forty-eight hours—and within ninety days he had lost forty pounds in weight, which was never recovered. He at once placed himself on a diet of meat and eggs, and lived largely upon this kind of food for seven years. A whole chicken or a pound of meat and four eggs was but an ordinary meal for him.

"Although living a quiet life, he yet occasionally indulged in long walks, and on returning from one of these on a warm day, very much overheated, he very imprudently plunged into a bath of cold water, and, as he expressed it to me, he 'thought he was done for,' as he had a severe struggle for life. But, as above stated, he lived for seven years, a large portion of the time secreting an unusually large quantity of sugar for a case of the kind, and, after being confined to the house for a few months, died with heart disease. To show the tendency to heart disease in his family, I might state that his half-sister died within a year with much the same symptoms as those which attended the last few months of his illness."

Concerning the same case Dr. Rudderow writes:

"Dr. K—— was in perfect health prior to the spring of '75, when at that time—I think it was in May—he took the gas. I saw him about twenty minutes after he had left the dentist's. He came into the house complaining of a sensation as if some one had him by the throat and was choking him. His pulse was feeble, his face pale, and the angles of the mouth drawn. He had headache, but no sick stomach. Heart and lung sounds were good. He remained in that condition nearly all day. The next morning, on passing water, he noticed that there was blood. Some time after—within a week or ten days, I think it was—he discovered sugar in his urine. From that time his kidney trouble gradually grew worse, and heart complications followed, which finally resulted in death."

Dr. James J. Levick, his attending physician during his last illness, makes the following statement concerning the case: "I was first called to see Dr. K—— professionally December 19, 1881, and I attended him until the time of his death, March 27, 1882. When I first saw him he had general anasarca, with abdominal effusion, a dilated heart, and, if I remember aright, albumen in his urine. There was nothing

unusual in his symptoms, and they were readily referable to the ordinary causes of heart and kidney disease."

Dr. Rudderow also reports a second case as follows: "The second case was a man whom I saw in February, 1879, and who two months prior to my attending him, according to his statement, went through much the same experience as Dr. K——, with the exception that from the day following his taking the gas he became almost blind. When I saw him he had albumen and casts in his urine, and on examining his eyes there were in the retina evidences of albuminoid retinitis. He stated that he was in perfect health up to the time of taking the gas; had never had anything the matter with him; had never had syphilis, and, indeed, was a perfect specimen of manhood, with the exception of his kidney trouble, Bright's disease, of which he ultimately died."

A third case is reported by Prof. Peirce, as follows: "Mr. P—— was a man in apparent good health, attending daily to his business, a good feeder, and fond of the pleasures of the table. In weight he was not much short of two hundred pounds. By my advice he went to Dr. —— and took the gas for the extraction of roots and teeth, which was successfully done with one administration. Within two days I saw him in his room on a couch. His statement to me was that on returning to consciousness he felt dizzy, and that this vertigo continued for some days. When the impression of his mouth was taken for an artificial denture he complained, as he sat in a chair in his bedroom, that his head was full and dizzy; his face was somewhat flushed. He informed me that his physician had discovered albumen in his urine. He lived for a little over a year, but was never able to do more than be helped into his carriage for a short ride. I have been informed that during the last few months of his life he suffered from sugar in his urine, but of the correctness of this I cannot learn definitely."

There is every probability that in all the above cases there were preexistent organic or functional derangements, possibly so slight in character as to be unobserved, and that the partial asphyxia produced by the inhalation of nitrous oxide intensified the symptoms and precipitated a crisis which otherwise might have been much longer deferred, or under proper care and treatment entirely avoided.

This opinion finds ample confirmation in the recently published observations of Dr. Laffont,[1] which observations have so important a bearing upon the subject under consideration that they are here reproduced:

"It is generally believed that the only danger from the use of nitrous oxide as an anæsthetic, according to the method of surgeon-dentists, consists in the danger of immediate asphyxia resulting from the absence of pure oxygen in the gas breathed during the inhalations.

"As the result of a conference upon anæsthesia that I have made in the present year (1885) at the Institut odontotechnique de la Rue de l'Abbaye, I have been in communication with a great number of surgeon-dentists who came to ask of me information and counsel upon the employment of

[1] "Contre-Indications aux Inhalations de Protoxyde d'Azote pur," par le Docteur M. Laffont, *Comptes rendus hébdomadaires des Séances de la Société de Biologie*, Dec. 4, 1885.

anæsthetics. I have profited by my relations with some of these gentlemen to learn if certain pathological conditions appearing at first view to have no relation to that method of producing insensibility, but still appearing after it, may not have as their point of departure or occasional cause that method of anæsthesia itself, however innocent it may appear.

"I was much the more interested in these researches as I had had under my care persons having had unfavorable symptoms following insensibility caused by inhaling pure nitrous oxide gas.

"The following are the observations furnished me by various surgeon-dentists; my own also are included:

"*First Case.*—Mrs. V——, aged thirty-five years, pregnant four months and a half, having had two living children born at the end of term, as the result of intolerable dental neuralgia, which did not yield to any anodyne, went to have extracted a tooth which appeared to be the cause of the neuralgia.

"Mrs. V—— was in good condition, had never vomited nor had symptoms of a nervous nature; she was, however, much afraid, and her physician recommended that she should take an anæsthetic in order to have the tooth extracted. The surgeon-dentist with an assistant began the inhalations.

"Mrs. V—— did not readily yield to the influence of the anæsthetic, but turned spasmodically and had contractions of the limbs. The inhalations, however, were continued, and at the end of a minute and a half, the patient being cyanosed, the tooth was extracted without pain.

"The patient awoke a little stupefied, and had a headache, but was without knowledge of what had happened.

"The dentist lost sight of Mrs. V—— for more than a year, when she returned to his office accompanied by her husband and requiring care for her teeth other than extraction. Mr. V—— entered the operating-room before his wife and begged that no allusion to the previous extraction of the tooth be made, because after the anæsthetic had been taken Mrs. V—— had been in a deplorable state of health, with daily nervous attacks—that she had had no appetite and frequently vomited, and finally, a month and a half after the operation, had a miscarriage, the fœtus being in a state of maceration, the death probably dating from the day of the operation, as after that day Mrs. V—— felt no movement of the fœtus.

"*Second Case.*—Miss M——, aged fourteen and a half years, having been for five months perfectly regular in her menstrual flow, presented herself at the office of another surgeon-dentist for the extraction of a molar attacked by caries. This young girl had the appearance of the most robust health: her menstrual period was not due for ten days.

"Anæsthesia was produced by inhalations of nitrous oxide, which produced unconsciousness very quickly, and in which the cyanosis was very marked. Two teeth were extracted without pain: the patient awoke promptly, although cyanosed. An appointment for the extraction of two other teeth was made for the fifth day after the cessation of the next menstrual flow. The second appointment, however, was not kept, and the dentist, going for information, learned that since taking the anæsthetic the young girl had become pale, had lost strength, ate nothing, had changed singularly, and had frequent attacks of hysteria. The physician feared a chlorosis of a grave character. Miss M—— had had no menstrual flow at the usual time.

"*Third Case.*—A young student, Mr. P——, aged nineteen years, went to the office of a well-known surgeon-dentist to have the roots of the large

inferior second molar on the right side extracted. The young man desired to be anæsthetized, because he had had when young a nervous disorder, and he feared that the extraction of the roots would require so much time that it would provoke a new crisis. He breathed copiously of the gas under the inhaling mask, and at the tenth respiration he twisted and became convulsively insensible. The dentist prepared to pull out the roots quickly, but he perceived that the patient no longer breathed. He hastened with his assistant to produce artificial respiration. Soon the patient became conscious, but was at once attacked with epilepsy. After a necessary rest he left, promising to return for the operation, which was to be performed without an anæsthetic. After some days the dentist received a letter in which he indefinitely postponed the operation, as since the administration of the anæsthetic the young student had been taken at the same hour each day with an attack of epilepsy.

"*Fourth Case.*—One of my patients, aged fifty-four years, suffering from diabetes, was treated with arsenic and the bromides, with which I succeeded in considerably diminishing the amount of sugar in the urine, it having decreased from 94 grammes to 8 grammes to the liter. But my patient, otherwise fairly well-conditioned, was attacked by general caries of the teeth, which frequently happens in the course of diabetes. He went to a dentist and desired to be anæsthetized, which was done. All passed normally, and the patient returned home well pleased. The night following, however, a thirst which had nearly disappeared returned with great intensity, as well as dryness of the mouth and of the general surface of the skin.

"I was called in the next day, and I asked if the patient had been alarmed or excited by the operation, but ascertained that such had not been the case. The urine gave 47 grammes of sugar to the liter, and this condition lasted for about three weeks; then the sugar fell gradually to its normal condition of from 7 to 8 grammes each day.

"I had no thought of the anæsthesia by nitrous oxide having caused the increase of sugar, and three months afterward my patient had another tooth extracted by the same process, with the same success. But the night following the same train of morbid phenomena was produced, and this time the sugar increased to 66 grammes to the liter, and it was only after one month and a half of rigorous treatment that it decreased to the normal condition of from 7 to 8 grammes. Noticing *then* that this aggravation of the diabetes coincided with the anæsthesia by nitrous oxide, I requested my patient in case he suffered again with his teeth not to be anæsthetized. Five months after, according to my advice, he submitted to a dental operation without the use of nitrous oxide, and this time the operation was not followed by any recrudescence of diabetes.

"*Fifth Case.*—An usher of the Sorbonne, to whom I had given my care while I was demonstrator for the chair of physiology, was attacked with mitral insufficiency, the results of which were confined to a dyspnœa variable in intensity: he had never yet had dropsy or albuminuria.

"I was called one day to this patient, and found his legs swollen. I examined his urine and established the presence of albumen. Seeking then for the date of the production of these phenomena, I learned that eight days before the patient had gone to have a tooth extracted, submitting to anæsthesia by nitrous oxide. Since then the dyspnœa had increased and the legs had swollen; pulmonary obstruction had followed, and consecutively albumen had appeared.

"Limiting ourselves to these five observations, which show us accidents

of the most varied character immediately following from the same cause, let us seek the relation of the accidents with this single cause.

"Is it nitrous oxide, considered as a chemical compound, that must be incriminated? Is it anæsthesia in general that is the productive agent? Is it the asphyxia that accompanies the production of anæsthesia by pure nitrous oxide?

"*As a chemical composition,* the researches of Hermann in 1864 have demonstrated that nitrous oxide is not injurious by itself, since mixed with oxygen in the proportions of the air it can be breathed indefinitely, without, however, causing anæsthesia. It does not displace the oxygen in the blood; it is not decomposed by it, but remains in a state of solution simply as an indifferent gas.

"*As an anæsthetic agent,* although experimental physiology and pathology may not have attempted anything from this point of view, it has not been explained how a regular normal anæsthesia could be able to produce here an abortion, there a chlorosis, elsewhere the reappearance of epilepsy, or, again, the appearance of dropsy and of the albuminuric cachexia. Surgeons, to my knowledge, have never noted similar accidents as the result of surgical anæsthesia.

"As to the production of diabetes, it might be, so to speak, that after the administration of chloroform there might be an appearance of diabetes, chloroform, as is known since the labors of Cl. Bernard, reducing the liquor of Fehling. I have, however, a personal case which permits me to stand up against this theory. Two years ago—when, in fact, I had not yet given my attention to the possible relations of anæsthesia with diabetes—I was present at a case in which anæsthesia was produced for the reduction of a dislocation of the shoulder of a robust man. I had the curiosity to ascertain if the chloroform was passing in sufficiently large quantity in the urine to produce the reduction of the liquor of Fehling. I ascertained that 30 cubic centimeters of discolored urine did not reduce 4 cubic centimeters of the liquor of Fehling. The next day the same result, whence I can conclude that anæsthesia itself cannot be considered as the factor of the accidents which happened in the observations I have just quoted.

"It is certain, then, as has been established by Jolyet and Blanche in 1873, that asphyxia always accompanies anæsthesia produced by the inhalation of nitrous oxide in a pure state. These physiologists have demonstrated by experiment that insensibility does not begin until there is more than from three to four per one hundred of oxygen in the liquor sanguinis; that is to say, the conditions are the same as where anæsthesia is produced upon asphyxiated animals, according to the studies of M. Paul Bert.

"This result was so striking that it was therefore doubted if nitrous oxide was a real anæsthetic; and the researches of Goldstein in 1876, and also those of Paul Bert in 1879, were necessary to establish definitely the anæsthetic properties of this gas.

"I believe that the state of asphyxia inseparable from the state of unconsciousness necessarily required for the painless extraction of a tooth must bring sufficient disturbance in the placental circulation, and consequently in the fœtal circulation, to provoke an abortion. From another point of view, in an organism so delicate as that of a young girl at the period of adolescence this state of asphyxia can lead to disorders leaving a lasting impression, as that of which I have given an example.

"On the other hand, I understand without explanation that asphyxia in the case of those affected with cardiac disorders aggravates a situation

already complicated by the impaired functional power of the central organ of circulation.

"As relates to the reappearance of epilepsy after an anæsthesia produced by nitrous oxide, it is admitted that cerebral excitation provoked by deoxygenated blood is able to produce a pathological cerebral state as yet imperfectly understood.

"But it is very sure that for the aggravation of diabetes following insensibility produced by the inhalation of nitrous oxide one should hold exclusively responsible the asphyxia which is a necessary concomitant of anæsthesia produced by nitrous oxide. In fact, M. Dastre has demonstrated that during asphyxia there is produced a veritable shower of sugar (*une véritable pluie de sucre*) in the blood; and this shower of sugar in a diabetic person under the influence of the inhalation of nitrous oxide gas adds to and aggravates the pre-existing pathological state, as the observations which I have cited prove.

"It is possible even—and I am now making some experiments on this subject—that in an animal or in a person not diabetic anæsthetized by inhalations of pure nitrous oxide there is promoted a temporary diabetes more or less durable.

"I shall make known subsequently the results which I shall obtain.

"What conclusions should I draw from these researches?

"From a purely medical point of view, I will say that anæsthesia produced by inhalation of pure nitrous oxide *is possibly never inoffensive;* that it should be formally prohibited—1st, with pregnant women; 2dly, with young girls at the period of adolescence; 3dly, in the case of persons susceptible to grave nervous disorders; 4thly, in the case of all disposed to cardiac affections; 5thly, in the case of all diabetics.

"In all these cases, when through fear of pain the patient demands to be rendered insensible, chloroform should be used—an agent so easily obtained, so constant in its results, so inoffensive, I may say, when the method so much praised by M. Paul Bert and the apparatus of Dr. Dubois are employed.

"From the point of view of administrative foresight, it should be rigorously forbidden to surgeon-dentists to practise anæsthesia by the administration of nitrous oxide without the assent and assistance of a doctor of medicine. Thus, one would be informed not only of accidents resulting in immediate death—which, happily, are very rare, and which excite the public—but yet, and above all, the secondary accidents, much more numerous, that the same public ignore, notwithstanding their gravity, for the reason that it is difficult to trace their origin back to their first cause—anæsthesia by pure nitrous oxide."

Conclusions.—The writer has no doubt that when attention has once been directed to the subject a much greater body of evidence than has here been presented will be massed in support of the position that the condition of asphyxia incident to anæsthesia by nitrous oxide, when produced in the ordinary manner, is "possibly never inoffensive," and that the gravest pathological manifestations are among its possible results. Thus is afforded still another confirmation of the principle, already incontrovertibly established, that any form of general anæsthesia is a condition of danger, and that on the part of those who assume the grave responsibilities necessarily incurred by the administration of anæsthetic agents there should be demanded the highest intelligence, skill, and learning. The extent to which these requirements have in

the past been disregarded, not only among dental, but among medical practitioners as well, needs no comment. With the advanced opportunities for a higher technical training which all progressive dental and medical schools now offer there can be no further justification for ignorance and incompetency, and they must soon cease to be tolerated.

DEATHS FOLLOWING THE INHALATION OF NITROUS OXIDE.—*First Case.*—The first recorded case of death following the inhalation of nitrous oxide appeared in the following report to the *New York Tribune* of Wednesday, January 13, 1864:

"Mr. Samuel P. Sears, a merchant doing business at No. 23 Park Row, on Monday evening called at the establishment of Dr. Joseph Burnett, dentist, No. 373 Canal street, and requested him to extract two or three decayed teeth, also requesting the dentist to administer to him nitrous oxide gas, better known as 'laughing gas.' Mr. Sears being, to all appearances, in perfect health, the operator administered the gas and drew the teeth. The patient seemingly recovered from the effects of the inhalation and went into an inner room, but soon returned and complained of shortness of breath, and sank on a sofa, expiring in a few moments. The deceased was removed to the residence of his parents, No. 274 West Twenty-second street, where an investigation by Dr. George B. Benton revealed the fact that the lungs of the deceased were very much diseased. Dr. Benton is of the opinion that the quantity of gas inhaled would have no injurious effect on a person in ordinary health. Coroner Wildey held an inquest on the body and the following verdict was rendered by the jury: 'We find that deceased came to his death by congestion of the lungs caused by inhaling nitrous oxide gas. We exonerate the person who administered it, but recommend that hereafter an examination be made, by a competent person, of any one who contemplates inhaling said gas.'"

Second Case.—The second case is reported in the *New York Tribune* of February 18, 1864, in the following terms:

"We have now to report another casualty. On the 1st of this month a travelling dentist, at a public exhibition of laughing gas at Swanton Falls, Vermont, administered the gas to several persons. Among the number was a beautiful girl, seventeen years of age, the daughter of W. H. Bell, Esq., a highly respectable citizen. The day after inhaling the gas she was taken ill, although she did not take sufficient to produce insensibility, and died the following day from its effects. Miss Bell presented a strong, robust physical constitution, and was in apparent good health previous to inhaling the gas."

Third Case.—The *New York Tribune* of Feb. 26, 1864, contains the following:

"Another victim is now to be added to the record. As an effort is making to hush the matter in the grave of the deceased lady, her name is not forthcoming. She lived in Allentown, Pennsylvania, and until application to this dentist was generally considered a very healthy woman. This lady applied to have laughing gas administered for painless dental surgery. After having inhaled the gas a few hours placed her in her grave."

Fourth Case.—Charles Kidd, M. D., in a communication to the *Medical Times and Gazette*, London, March 12, 1864, reports that—

"One death has just occurred in a dentist's chair from the administration of nitrous oxide. It was that of a fine young woman in perfect health, who was induced to have this agent rather than chloroform."

Fifth Case.—From the *Medical and Surgical Reporter*, Philadelphia, February 2, 1867:

"Last week Edmund Kerosen, a young man twenty-three years old, entered the office of Dr. Ralph Lee, a dentist of this city, to have a tooth extracted. Anæsthesia was produced by nitrous oxide gas, a cork having been placed between the teeth to keep the mouth open. As the tooth was extracted, we understand, it slipped from the forceps, and with the cork was drawn into the mouth. The tooth was subsequently thrown up from the stomach, but the cork—which does not seem to have been missed—entered the larynx, and by its presence there caused suffocation and death in an hour. A post-mortem revealed the presence of the cork in the larynx and the cause of death."

Sixth Case.—In 1872 in the office of a New York dentist a death occurred which a coroner's jury pronounced to have been "induced by the inhalation of gas administered." The facts concerning this case are given in an editorial in the *Dental Cosmos* (vol. xiv. p. 311):

"From a pamphlet issued by Dr. Newbrough, at whose office the event occurred, we make the following summary of the evidence before the coroner's jury: Dr. Newbrough testified that the patient, a middle-aged lady, desired the extraction of seven or eight front teeth which were *loose*. Dr. N—— advised that their removal would be so easy that an anæsthetic would be unnecessary, but the patient insisted that she could not submit to an operation without it. Dr. N—— then procured a six-gallon bag of gas, but the patient seemed about equally fearful of anæsthesia and pain, and as soon as she had made an inhalation rejected the bag and declared her willingness to have the operation performed without it. At sight of the forceps her courage again failed her, and she decided once more to try the gas. She took one inhalation and again rejected it. By this time so much of the gas had escaped from the bag that the doctor replenished it. Of this she took two inhalations, and peremptorily refused to have anything more to do with it, declaring her determination to submit to the operation. The teeth were then extracted. 'Immediately,' says the doctor, 'she *fainted*, her head dropping over sideways.' The face rapidly became livid, and finally purple, respiration falling to about fifteen per minute. In about thirteen minutes, notwithstanding the prompt application of the galvanic battery and efforts to assist respiration, death ensued. The muscular system was entirely relaxed throughout, and after death the face became instantly blanched.

"Dr. Otis, summoned by Dr. N——, and arriving in about ten minutes after the fainting, testified that he continued the usual restorative treatment for forty-five minutes, when death ensued. At post-mortem found no disease of the heart; brain perfectly exsanguinated in every part; no fluid in any of the ventricles. One lung was more engorged than the other, but healthy."

The coroner's jury, consisting of ten doctors of medicine, rendered the following verdict:

"We find that Mrs. Ann O'Shaughnessy came to her death from asphyxia

or apnœa, as evidenced by the symptoms manifested by the patient before death and the conditions found at the post-mortem, the asphyxia having, in our opinion, been induced by the inhalation of gas administered."

This is followed by censure of Dr. Newbrough for using imperfect apparatus in making the gas, only one wash-bottle having been used. Concerning this verdict the *London Lancet* remarks:

"The nitrous oxide could have had no more to do with the fatal issue, either directly or indirectly, than if it had never been brought into the room. The patient manifestly fainted from terror, doing so as soon as her state of mental tension was relaxed by the operation being completed. Her syncope was just a result of the reaction of an overstrung nervous system; and if Mr. Newbrough had only laid her flat on the floor she would probably have recovered in five minutes, have paid him his fee, and have walked away from West Thirty-fourth street as well as she entered it. It was the unwisely holding her upright that determined the fatal issue; and, although one must sympathize with the queer medical jury to the extent of admitting that no anæsthetic agent should be entrusted to a man who treats syncope by the erect posture, yet still when we consider the wide prevalence of his error, we must not be too hard on the dentist. . . . .

"The absence in Mrs. O'Shaughnessy's case of any apparent cause for sudden death other than emotional syncope and the upright posture, and the entire sufficiency of these to explain the occurrence, seem to render the verdict of the New York jury one of the most astonishing on record."

Seventh Case.—"In Chicago, October, 1871, a patient died in the office of a dentist, under the influence of nitrous oxide, two or three days before the great fire which destroyed the most important part of the city. As a consequence of the confusion produced by that event, the fact of this death became known to very few persons, and was soon forgotten."[1]

Eighth Case.—From the *London Lancet,* Feb. 1, 1873, the following is taken:

"A death from the inhalation of nitrous oxide occurred at Exeter in the afternoon of January 22d of this year. The gas was administered by Mr. J. T. Browne Mason, a dentist in Exeter, for the purpose of securing the painless extraction of a large upper molar tooth from a patient under the care of Dr. Pattinson. As this is the first instance of a death from the gas that has been reported upon in this country, the facts are worthy of a special record."

These facts are thus reported by Mr. Mason in a communication to the Odontological Society of Great Britain:[2]

"Miss Wyndham [the patient] was thirty-two years of age, and generally enjoyed good health. There was considerable disorder in the arrangement of the teeth, the second bicuspid on the left side of the upper jaw having what should have been its posterior surface against the lingual surface of the second molar. This tooth had been the subject of so much caries that a probe could be passed right through. The pulp was gone, and there was excessive periosteal inflammation. It was not possible to remove a second molar with the ordinary forceps without disturbing the bicuspid, so Mr. Mason decided to cut off the crown of the diseased tooth, thus separating the fangs,

[1] From *Artificial Anæsthesia and Anæsthetics*, Lyman, p. 325.

[2] *British Journal of Dental Science*, vol. xvi. pp. 126, 127.

and then remove them singly. The patient was accompanied by her usual medical attendant, Dr. Pattinson. The gas (liquid prepared by Ash & Son of London) was administered in the ordinary way, the patient being seated in a Morrison's chair. The gag used was an ordinary wooden one, and was inserted between the first molar and the second bicuspid. Dr. Pattinson took charge of the pulse in the left wrist. After half a dozen respirations he said the pulse was not so rapid, but its volume had not varied. Mr. Mason then removed the facepiece and cut off the crown of the tooth with the excise forceps. On his thrusting this instrument into the exposed pulp-cavity and twisting the fang, so much pain was caused that the patient declared she could not bear any further operation unless more gas was administered. On rinsing out her mouth the water was tinged with blood. After an interval of ten minutes, the bleeding having quite ceased, the gag was replaced in its former position. Dr. Pattinson, however, thinks there must have been a minute quantity of blood exuding from the gum at the second inhalation. Mr. Mason took charge of the pulse at the right wrist, Dr. Pattinson again having charge of the left, and gas was again administered. Just before losing consciousness the patient raised her hand and pushed off the inhaler, but it was put back. Mr. Mason then attempted to seize the patient's fang with a pair of stump forceps, but, the edge giving way, he dislodged it with an elevator, with which he afterward easily removed the entire fang. The whole operation lasted about three-quarters of a minute. He received all the fragments of the teeth in his fingers, and felt quite sure nothing passed backward. He then for the first time saw the blueness of the face, but Dr. Pattinson had noticed it before. The symptoms then became alarming: the features appeared puffy and swollen, the eyeballs protruded, the breathing became thick and stertorous. The pulse was not observed. An old attendant, who was in the room, exclaimed, 'Take off the gag; she is choking.' It needed great force to separate the jaws, and possibly the gag was then chipped. It was only ten days after the operation that Mr. Braine pointed out for the first time the broken surface of the gag. The head was then thrown forward to prevent any blood from getting into the throat, and Mr. Mason passed his finger over the tongue to draw it forward. From this time Dr. Pattinson was of the opinion that there was fixity of expression and no further entrance of air into the chest. The window was thrown open and cold water dashed in the patient's face. Mr. Mason then went for further assistance, while Dr. Pattinson applied strong ammonia to the nostrils, after which he noticed some water lying in her tongue at the back of her mouth. This he caused to run out by drawing the head forward. When Mr. Mason returned with Dr. Drake the countenance of the patient was black, the face swollen, eyes projecting. Dr. Drake put his finger into the throat, and she made three or four expiratory movements accompanied by a slight sound. The pulse continued to beat regularly for two minutes after the expiratory movement had ceased. Two and a quarter hours after death the blueness had entirely disappeared. It was much to be regretted that a post-mortem examination had not been held."

At the official examination held in this case Dr. Drake testified as follows:[1]

"I am a physician residing in Exeter. Yesterday I was called by Mr. Mason to examine Miss Wyndham. She was sitting in a chair, half reclining, before an open window. Dr. Pattinson was by her side endeavoring

[1] *Op. cit.*, p. 87.

to restore animation. Her features were livid, swollen, and she appeared to be quite unconscious. She breathed a few times, but a short time afterward her pulse ceased to beat. I consider the cause of her death to be paralysis of the parts which regulated her breathing, arising from the administration of nitrous oxide gas, which produced asphyxia."

Ninth Case.—This is a case that excited great attention at the time of its occurrence, owing to the fact that the patient was a surgeon in good practice in Manchester, England. His death occurred in that city March 27, 1877. Mr. Harrisson, it appears, had been suffering from an aching tooth or teeth, and went alone to a dentist, Mr. E. H. Williams, for the purpose of having them extracted. As Mr. Williams was the only witness to the events which followed, his testimony is given:[1]

"I tried to take one tooth out, but deceased, being sensitive, wished to have gas, which I administered in the usual way. I asked him to wave his hand when he had had sufficient. He seemed excited, but it must have been from pain. He said he had had nothing to eat that day and could not live on stimulants. I tried, judging from his appearance that he was ready, to extract the tooth, and then deceased said he must have the gas until he snored. I gave him the gas until he snored, and extracted two teeth. Seeing that he was not coming round, I opened the window to admit air, flapped him, and sent for Dr. Noble."

Upon the arrival of medical assistance Mr. Harrisson was found dead. The post-mortem revealed a great deposit of fat encumbering all the organs, especially the heart. There was enlargement of the liver, due to fatty degeneration, and commencing disease of the aorta and valves of the heart. A great quantity of fluid was found within the cavity of the brain, and there was a general venous engorgement and a fluid condition of the blood. The cause of death was decided to be "sudden failure of the heart's action," although this verdict was vigorously dissented from by many medical writers, who pronounced the death to be due to asphyxia pure and simple.

Tenth Case.—W. Roger Williams, F. R. C. S., surgical-registrar to the Middlesex Hospital, reports the following case:[2]

"This patient, a well-nourished and fairly healthy man, aged fifty-seven, was admitted into the Middlesex Hospital on August 21, 1883, under the care of Mr. Andrew Clark, to whom I am indebted for permission to publish the case. He then presented a considerable cancerous enlargement of his tongue, which was hard and fixed and in places slightly ulcerated. The induration extended from near the tip as far back as the circumvallate papillæ, and involved most of the organ. There was dribbling of saliva. The submaxillary and submental glands on both sides of the neck were enlarged and hard. There was no obvious interference with the respiratory function, but the mouth could not be opened to its full extent. He had been subject to small ulcers on the tongue for several years previously; when young he had chancre and bubo, but there was no other history or sign of constitutional syphilis. His general health had previously been good. There was no history of phthisis, tumor, or cancer in his family. Three months ago he first noticed hardness and stiffness of the left side of the tongue at about its

[1] From *Medical Times and Gazette*, April 28, 1877.
[2] The *British Medical Journal*, October 13, 1883.

middle, which, he said, started in connection with a small sore previously there. The tongue had since been getting larger and harder, but he had had no pain in it. The glandular enlargement was first noticed only a few weeks before his admission into the hospital.

"On the morning of September 15th he was sent to the Dental Hospital in Leicester Square to have some teeth extracted. Gas was administered by the house-surgeon, the patient sitting in the arm-chair in the usual way. The requisite degree of anæsthesia was produced, as far as could be judged, in about thirty seconds. No alarming or unusual symptoms were noticed until the operator was about to begin the extraction, when the patient seemed breathless and even lifeless; then the tongue was drawn forward, water was dashed in the face, and artificial respiration was resorted to, and various other means of reviving were tried for upward of half an hour, at the end of which time they were abandoned, as the patient was evidently dead. About a week previously he had some teeth extracted without the gas, and no unfavorable symptoms occurred then.

"I made the necropsy forty-nine hours after death, the weather being close and fine. The body was well nourished and fairly muscular, and there was a slight degree of rigor mortis present. The back of the head, neck, trunk, and thighs presented a deep purplish discoloration. In reflecting the scalp from the forehead the quasi-fluctuating swelling in this situation, which had been taken for a sebaceous cyst, turned out to be a lipoma. The dura mater was very firmly adherent to the calvarium, and came off with it. In other respects the brain was normal; it weighed fifty-five ounces. The heart was examined *in situ*. There was about the normal amount of fluid in the pericardial sac. Near the apex the visceral pericardium presented a few small whitish patches of fibrous thickening. The organ was rather large and its chambers patent; it weighed twelve ounces. Each ventricle contained about a drachm of fluid blood, but the auricles were empty. The valves were normal, with the exception of a soft miliary fibrinous vegetation in one of the aortic valves, and, as far as could be judged, they were competent. The muscular substance appeared healthy, and there was no indication of fatty degeneration. Evidently, the heart's action had been arrested in diastole, death resulting from syncope. The right lung was firmly bound to the chest-wall throughout its whole extent by old fibrous adhesions; its lower lobe was collapsed, atrophic, and non-aërated, the liver having encroached here on the chest-cavity. The left lung was large and slightly congested, presenting a few small emphysematous sacculations along its free anterior border; in other respects it was perfectly healthy. There were no subpleural ecchymoses or other signs of asphyxia. The left lung weighed nineteen ounces, the right thirteen. The liver was normal; its weight fifty-five ounces. The spleen weighed nine and a half ounces, and was rather large, but otherwise normal. Both kidneys were congested, and presented several small cysts and a few small cicatrices on their surfaces. There were several fibrous patches in both testes, where the secreting structure was destroyed. With regard to the blood, the only obvious change was the absence of clots in the great vessels. A firm whitish mass of cancer, about the size of a small apple, occupied the greater part of the tongue, but the mucous membrane over it was not extensively ulcerated, presenting only a few small erosions; it extended as far back as the circumvallate papillæ. Neither the epiglottis nor the glosso-epiglottidean folds, nor any part of the larynx, was invaded by it. The vocal cords, the rima, and the ventricles were normal. The mucous membrane of the bronchus and its primary divisions was lined with viscid

mucus, and its capillary vessels were injected. There were some enlarged and cancerous glands on both sides of the neck."

Eleventh Case.—This occurred in November, 1884, in the office of M. Duchesne, a dentist of Paris. The essential facts relating to the case are contained in the following report of the legal proceedings which were instituted in the case. The report is of interest as showing the status in France, under the law, of dentists other than those who are doctors of medicine, and is here reproduced in full:[1]

"Tribunal Correctionnelle de la Seine (8e Chambre), présidence de M. Mersier, audience du 27 Novembre, 1885.

"Homicide caused by imprudence of M. Duchesne, dentist, death of the patient by asphyxia, Law of Ventose,[2] Year XI., Major Surgical Operations. Decision of the tribunal:

"At the hearing on this day the judge gave in this case the following opinion:

"Whereas, the result of the testimony and of the discussions is that on November 25, 1884, Monsieur Lejeune went to the office of Duchesne to have a tooth extracted;

"That at the request of the patient the dentist gave him nitrous oxide in order to render the patient insensible to the operation;

"That as the result of these inhalations M. Lejeune fell into a syncope which was followed by death;

"Whereas, in this operation Duchesne should have been assisted by a doctor of medicine;

"That the act of administering nitrous oxide requires that the operator have a thorough knowledge of physiology; that he be allowed to examine beforehand, with care, the condition of the organs of the patient desiring the anæsthetic;

"That whatever the experience of the accused may be—experience which suffices in most cases, but not in all—this lack of special knowledge is wanting in Duchesne, who is neither a medical doctor nor an officer of health, though he assumes the qualifications of doctor of medicine;

"That a thorough medical examination of M. Lejeune was very necessary, since his physician knew him to be a man who could not inhale any anæsthetic without danger;

"Whereas, Duschene so fully realized his mistake that in order to exculpate himself he hastened to assert, contrary to the truth, that he had been assisted by a doctor of medicine;

"Whereas, one of the experts, Dr. Brouardel, who was heard at the examination, is of the opinion that for the application of an anæsthetic two competent persons are necessary, of whom one at least should be a doctor of medicine, and that to administer an anæsthetic without observing these conditions is a great imprudence: the same witness testified also that in this particular case it was a special imprudence to give nitrous oxide to M. Lejeune in view of his constitution; that if it had been a question of an operation for a grave malady it would have been admissible to practise on M. Lejeune this mode of anæsthesia, but not when, to quote the language of the witness, it was given out of complaisance and to spare him a little pain in a trifling operation;

[1] From *Le Progrès Dentaire*, Décembre, 1885.
[2] Sixth month of the calendar of the first French Republic, from 19th or 20th of February to 20th of March.

"Whereas, on the other hand, among surgical operations the extraction of a tooth must be generally considered as an operation without any importance, and one which requires chiefly a certain dexterity, any dentist, even if not a graduate, can perform the operation; but when the act is accompanied by the administering of an anæsthetic it is not the same;

"That in this last case, according to the opinion of experts, it belongs to the class of major surgical operations;

"That as a conclusion from this, by the terms of the Article 29 of the law of 19 Ventose, year XI., officers of health, and for greater reasons dentists who are not graduates, have not the right to give an anæsthetic unless under the surveillance and inspection of a doctor of medicine;

"That such an operation is also a contravention of Article 35 of the same law, which prohibits the practice of medicine or surgery without any diploma;

"That a contravention of this kind, when it causes death or injuries, becomes one of the elements of the crime foreseen by Article 319 (Code pénal), which is exactly the crime attributed to M. Duchesne;

"Whereas, finally, the director of one of the dental colleges of Paris does not hesitate to recognize the necessity of the attendance of a physician when it is necessary for a dentist to administer an anæsthetic;

"Whereas, from the circumstances of this case the tribunal has no doubt that the mistake of Duchesne caused the death of Lejeune;

"That such are the conclusions of the experts which are expressed thus: 'We must consider the anæsthetic as having caused death;'

"That it is found that Duchesne did in Nov., 1884, in Paris, by imprudence, carelessness, and neglect of rules, commit an involuntary homicide on the person of M. Lejeune—a crime foreseen and punished by Article 319 of the Penal Code;

"Whereas, however, there exist extenuating circumstances, the penalty is reduced by the application of Article 463, in that which concerns the indemnity called for by the civil party;

"That whereas, from this point of view the court must only consider the material damages resulting to the widow from the death of M. Lejeune;

"Whereas, if this fact has caused the business affairs of M. Lejeune to be retarded, it has at the same time been a source of benefit to his family, since it has caused the annual payments of the policy of a life insurance, which M. Lejeune regularly paid up, to cease, and that the policy of forty thousand francs has been paid by the company;

"That we must also consider that the death of M. Lejeune was not only due to the fault of M. Duchesne, but also by the imprudence of the victim himself, who without consulting his own physician, or without having any medical doctor present, called for the application of an anæsthetic;

"That this imprudence justifies a decree of abatement against the claim of the prosecution;

"That in consideration of these circumstances the sum of three thousand francs is sufficient reparation; Duchesne is condemned to pay six hundred francs penalty to the state, and to pay to the widow of Lejeune the sum of three thousand francs damages. The prosecution is condemned to pay expenses except the fines required from Duchesne."

Summary of Cases.—In judging of the danger of death from anæsthesia by nitrous oxide in the light of the cases of fatality here recorded, Case No. 5 must, of course, be at once ruled out, death in this instance

being manifestly due, not to the gas, but to the prop, which produced suffocation.

In Case No. 2 the gas was administered by a travelling mountebank and showman, and in all probability was freshly prepared and in an improper manner, and administered almost as it came from the retort. The death, which resulted on the following day, might well have been caused by the inhalation of poisonous gases and vapors thus produced, and under the circumstances should hardly be scored against nitrous oxide as made and administered by careful and experienced operators to-day.

In Case No. 3 diligent inquiry has failed to substantiate the facts as represented. Dr. Edwin G. Martin, a lifelong resident of Allentown, and one of its leading physicians as well as citizens, says in a letter to the writer: "I have made inquiry in relation to the fatal case from the effects of laughing gas, and cannot find out who the person was. I do not think the lady was from Allentown. No one seems to know anything about the matter." In view of this fact it seems not unfair that this case should be thrown out of the count.

Concerning Case No. 4 there are no data. The sole evidence is the testimony of a reputable physician that a death from nitrous oxide took place in a dentist's chair, and that the patient was in perfect health before the inhalation of the gas. This case may be allowed to stand.

In Case No. 6 so little gas was given, and the symptoms were so evidently those of syncope after fainting, that nitrous oxide should not be held responsible.

Thus out of the eleven cases which have been reported at least four should be eliminated, leaving only seven cases of fatality fairly attributable to the inhalation of nitrous oxide gas out of the many hundreds of thousands of individuals to whom it has been administered since its general introduction into minor surgical practice.

Of the total number of such administrations it is impossible to form even an approximate estimate. Up to January 1, 1887, in a single establishment in this city the gas had been administered 142,780 times. The operator in charge, Dr. J. D. Thomas, writes: "We have never had a fatal case, and are not cognizant of there ever having been any ill effect subsequent to the use of the gas which was not readily accounted for otherwise."

Dr. F. Hasbrouck, a nitrous-oxide specialist of New York City, writes (January 1, 1887): "In the past sixteen years I have administered nitrous oxide to over fifty-two thousand people. I have kept some under its influence (profoundly anæsthetized) one hour and a quarter, many others from twenty to forty minutes. As far as I know, there have been no fatal cases. There have been dangerous symptoms, but they were all in cases of persons who had been afflicted with lung inflammations followed by pleuritic adhesions. In the cases referred to there seemed to be paralysis of the respiratory muscles and entire inability to expand the chest. In such cases my practice has been to place the patients with the head much lower than the feet and keep up artificial respiration. I have had from four to six patients who I think would have died had they not been promptly treated in that way.

After the ability to swallow is restored I administer brandy as soon as possible."

From the figures above given it will be seen that in but two establishments in this country there have been nearly two hundred thousand administrations of the gas, and without a fatal result. Taking into consideration that the agent is in constant daily use all over the civilized world, not only in large cities, but in the smaller towns and villages as well, it is evident that the aggregate number of administrations must have been so enormous as to reduce the percentage of deaths to an exceedingly small fraction, and that, so far as relates to immediate fatality, no anæsthetic agent now known can compare in safety with nitrous oxide gas.

Post-mortem Appearances.

There are no post-mortem appearances which can be said to be strictly characteristic of death produced by the inhalation of any of the anæsthetic agents usually employed: very often an autopsy gives entirely negative results, and very generally, apart from the odor of the drug employed, there is nothing to distinguish such cases from those in which death has occurred from syncope or asphyxia produced by other causes.

Appearances after Death from Sulphuric Ether.—The appearances presented in thirty-two cases of death following the administration of sulphuric ether have been collated by Lyman.[1]

In the First Case.—"The blood was everywhere fluid, very dark and viscous, resembling molasses in the posterior portion of the lungs. The anterior portion of the lungs was filled with frothy mucus: the respiratory mucous membranes exhibited a lively injection; the spleen was very soft."

In the Fifth Case.—"The subarachnoid fluid was more abundant than usual. Brain healthy. Heart soft and flaccid, containing yellow coagula in the right cavities, and a small quantity of fluid blood in the left."

In the Sixth Case.—"The blood was everywhere dark and fluid. The veins of the head contained a considerable quantity of air."

In the Ninth Case.—"The air-passages contained mucosities; the base of the left lung was hyperæmic, the pulmonary tissue itself being impregnated with the odor of ether. The heart was normal, its ventricles empty, its auricles gorged with blood; the nervous centres were healthy."

In the Eleventh Case.—An autopsy held three hours after death found the "blood fluid; brain and membrane normal; a little fluid blood in the heart; base of the aortic valves slightly atheromatous; pleural adhesions over both lungs; lower lobe of right lung œdematous and in a state of red hepatization; rest of the lung normal, but somewhat emphysematous."

In the Twelfth Case.—"The right cavity of the heart was full of dark fluid blood; the left cavity was nearly empty; the valves were healthy;

[1] *Artificial Anæsthesia and Anæsthetics*, pp. 289–297.

the muscular substance flaccid; the lungs were hyperæmic and brightly colored; the brain was normal; all the other organs were healthy."

In the Twenty-fifth Case.—"The heart-substance was slightly fatty; the cavities were nearly empty; no clots; lungs emphysematous; all the posterior parts engorged with blood."

In the Thirty-first Case.—"The autopsy, made the following day, exhibited some œdema of the membranes of the brain; no thrombosis of the pulmonary artery; heart healthy, containing a little blood in the right auricle; ventricles contracted; lungs pale and œdematous; other organs healthy." In the other cases either an autopsy was not held, or if held the results were negative.

In death following chloroform narcosis the appearances presented in the circulatory, respiratory, and nervous tracts are equally variable. Dr. Reese states[1] that "in death from inhalation there is very often no lesion discoverable. At times there will be found considerable congestion of the lungs and bronchial tubes, and likewise of the vessels of the brain, together with a dark and fluid condition of the blood."

The following table from Sansom[2] gives the results of post-mortem examination in fifty-one cases:

Fifty-one Cases of Death from Chloroform Narcosis.

Blood dark and fluid	24
Lungs congested	18
" " in depending parts	4
" loaded with blood	5
" normal	10
Heart, accumulation of blood in right side	17
(In three cases distended; in all the cases there was little or no blood in the left cavities. The blood was fluid in all but two cases. In one case air was mingled with the blood.)	
All cavities empty	9
(In one case contracted from spasm.)	
All cavities containing blood	13
(In one case a firm coagulum was found: galvanism had been employed.)	
Auricles empty, ventricles containing blood	2
Brain congested	9
" normal	14
" pale	7
Air in vessels of brain	1

Dr. Sansom states that an almost constant sign was darkness and fluidity of the blood.

Dr. Snow collated fifty cases of death from chloroform,[3] of the post-mortem appearances in which the following summary is given by Dr. John Chapman:[4] "Of these, thirty-four were examined after death. In three the state of the lungs is not mentioned, in four they are said to be normal, and in twenty-seven there was unequivocal evidence of mechanical obstruction to the action of the heart; the lungs were congested and the pulmonary artery and right heart distended with blood. In some only one of these characteristics is said to have been observed, but in the majority both were present."

[1] *Medical Jurisprudence and Toxicology.*
[2] *Chloroform, its Action and Administration*, p. 147.
[3] *Anæsthetics*, pp. 120–199.
[4] *Med. Times and Gazette*, Oct. 23, 1858.

As given by Tourdes,[1] the following are the principal appearances observed after death from chloroform :

"There is paleness of the face; the expression of the countenance is tranquil; the pupils are dilated; upon the limbs are visible rose-colored spots; there is very little appearance of cyanosis. At its base the tongue is sometimes injected; the retraction of that organ is the physical consequence of the attitude of the corpse when muscular contractility has ceased.

"The lungs are congested, and present a rose-colored tint or even a decided red coloration. This congestion may, in the lower animals, become a disseminated lobular engorgement. In forty-eight cases of autopsy pulmonary congestion has been noted thirty-six times. Sometimes there is serous infiltration of the lung. Great importance has been assigned to the pulmonary emphysema encountered in many cases: this is almost always observed in the lower animals, even if the sudden and convulsive forms of asphyxia have been avoided. Redness of the mucous surface of the trachea and bronchi has often been remarked. A certain amount of froth may be found in the air-passages: the degree of their injection will be more intense if, in a case of homicide or suicide, a few drops of chloroform have found their way into the respiratory tract—an accident which rapidly produces injurious results. It should be remembered that certain authors, among whom Casper may be found, have mentioned an anæmic condition of the lungs.

"A flaccid condition of the heart has been observed (sixteen times in twenty cases). This phenomenon, however, is principally dependent upon the time of the examination. The same remark is applicable to the condition of its cavities (fourteen times out of twenty cases). The muscular fibres of the heart have been found paler than usual. The heart may be filled with blood, especially on the right side. The great veins may be distended with blood, and there is often a sufficiently notable quantity of this fluid in the principal arteries. The blood is liquid, brownish, or of a deep-red color. This condition is rarely absent, Berend having remarked its presence fifteen times in twenty examinations. This fluidity of the blood is coincident with the rapidity of death. Sometimes we have noticed a few clots mingled with the fluid blood; in one case the blood in the left side of the heart had a very deep-red tint, indicative of sudden syncope. Very little importance should be attached to the presence of free gases in the blood, as this is a consequence of putrefaction, which may be very rapidly evolved. A chemical analysis would be necessary in order to determine the character of the gas. In twenty autopsies the presence of these gases was noted seven times. Putrefaction was progressing in three of these seven cases; in three cases the mode of death was doubtful; and in only one case could any value be attached to the observation (Berend).

"The pia mater and the cerebral parenchyma are moderately injected. Congestion is the exception, occurring only four times in forty-eight cases (Sabarth), and it is not considered a cause of death. An anæmic condition of the cerebral organs has been remarked. Their softening seems to be connected with putrefactive changes. We have noted a trifling amount of ventricular fluid. The liver is often congested. This organ is variously affected by the action of deleterious vapors and gases. Injection of the kidneys has been observed."

Appearances after Death from Nitrous Oxide.—In only four of the eleven recorded cases of death following the administration of nitrous

[1] In the *Dict. Encyc. des Sci. méd.*, t. iv. p. 505, from Lyman, *op. cit.*, p. 88.

oxide was a post-mortem examination made, or if made recorded: these cases were the first, the sixth, the ninth, and the tenth. In these cases the appearances were quite as various in their character as those found after death from ether or chloroform.

In the first case the lungs were found much diseased, and "death by congestion" was the verdict of the jury. In the fifth case a cork in the larynx was the cause of death. In the sixth case "the brain was perfectly exsanguinated in every part: no fluid in any of the ventricles. One lung was more engorged than the other, but healthy." In the ninth case "the post-mortem revealed a great deposit of fat encumbering all the organs, especially the heart. There was enlargement of the liver due to fatty degeneration and commencing disease of the aorta and valves of the heart. A great quantity of fluid was found in the cavity of the brain, and there was a general venous engorgement and a fluid condition of the blood." In the tenth case the general condition of the brain was normal. The normal amount of fluid was found in the pericardial sac. The ventricles of the heart contained about a drachm of fluid blood, but the auricles were empty. The blood in the great vessels was free from clots. The left lung was bound down by old adhesions and collapsed; the right lung was healthy.

Local Anæsthetics.

To produce local anæsthesia in painful parts is a primitive instinct of man, and has always been one of the chief offices of medicine. In the attainment of this end not only have such natural agencies as heat and cold, pressure and friction, been resorted to, but the whole list of narcotics has been tested by all possible modes of application, and with results which in the main have been far from uniform, or, as compared with general anæsthesia, certain or satisfactory. The reason for this relative failure is readily found, either in the resistance, greater or less, which superficial surfaces offer to the absorption of pain-obtunding agents, or in the fact that a large number of these exert their chief physiological effects through the nerve-centres, and act directly upon peripheral nerve-tissue only in a modified and lessened degree; so that the local analgesic effect of even so powerful a sedative as morphia is often quite insignificant, although it may have been applied hypodermically, and thus brought in direct contact with the tissues it was sought to influence. For these reasons not only have local applications for the relief of pain, but for its prevention, proved to a great extent ineffective.

Local anæsthesia of the teeth and their investments is, owing to their density of structure, especially difficult of attainment by medication. Applications to the dental pulp when fully enveloped by its normal coverings of dentine, enamel, etc. would appear to be almost futile. In those cases, however, when, as the result of caries or accident, these have been broken down and the pulp thus made accessible to the direct contact of anæsthetic or analgesic agents, very uniformly successful results are attainable; and, indeed, in such cases at least temporary relief from pain is almost invariable when the proper agent has been judiciously

applied. Even with so vascular an organ as the dental pulp, however, the anæsthesia produced is, as a rule, superficial and transitory, and while pain may be absent as long as the tissues are at rest, any attempt at surgical interference causes a renewal of the suffering, so that when pulp-extirpation is attempted its removal in mass under local anæsthetic influences is rarely practicable; and it is generally necessary to anæsthetize—and, in turn, excise—fibre by fibre, to the finest ramifications of the pulp-substance—a process even then not often to be accomplished painlessly.

The agents which will most readily effect local analgesia of the exposed dental pulp are creasote, carbolic acid, oil of cloves, and oil of cajeput, these to be used alone or in combination with morphia. A mixture made by rubbing up the acetate of morphia with enough oil of cloves to form a thin paste has, in the writer's experience, rarely failed to afford prompt relief in pulp inflammations. A sixth of a grain may be employed, this being placed in the affected tooth upon a pledget of cotton; and to secure its greater efficacy, as well as to avoid the possibly serious consequences which in the case of children might result from swallowing the drug, the application should be carefully sealed in the carious cavity with one of the softer preparations of gutta-percha, great care being taken to avoid pressure upon the exposed pulp during the process. The cavity should, of course, be previously well cleansed in order to ensure the close contact of the medicament with the exposed surface: this is a preparatory measure highly desirable in all cases, and often essential to success whatever agent may be employed.

In addition to the agents above named other volatile oils, such as oil of wintergreen and oil of eucalyptus, have been extensively used. The success of ether and chloroform in the production of general anæsthesia early led to a trial of their local anæsthetic effects, and they have been much employed, generally, however, in combination with other substances. But in pulp-exposure their volatility and the irritation of the gum-tissue which they produce when held in close contact with it interfere with their usefulness. A solution of camphor, either in ether or chloroform (ʒj to f℥ij) has been recommended, and when better means are lacking may be successfully employed.

Aconite has also been largely used in all forms of odontalgia. In the relief of pain arising from pulp-exposures the writer has not found it so efficacious as the preparations previously recommended. As an analgesic application in peridental inflammation it is hardly more successful, for although a distinct benumbing of the parts can be secured, this is usually but slightly alleviatory in character, and to obtain even this simply painting the gum with the tincture is quite a futile procedure. For its successful use free applications are necessary. The writer's practice is to saturate with the tincture quite a large pledget of cotton-wool and place it upon the gum-tissue over the affected tooth, allowing it to remain there for some hours, and renewing if necessary. There is with an adult no danger from this practice if the saliva is carefully ejected as it accumulates. With many practitioners combinations of aconite with iodine or with chloroform are favorite applications in this class of cases. As chloroform favors the inward osmosis of alcoholic solutions, that combination at least would appear to be justified on physiological

grounds, although if added to aconite in any considerable amount a prolonged application such as that just described for aconite alone would be exceedingly painful, and would inevitably cause the formation of a blister if not even more violent inflammatory effects. This too is true of combinations of aconite and iodine: only a simple painting of the gum is permissible, unless counter-irritant effects are desired. Iodine without admixture with aconite will frequently not only reduce the pain incident to the chronic type of peridental inflammation, but will also produce a marked amelioration of the other symptoms. This result may be due in part to contraction of the congested capillaries, but in the writer's opinion iodine in the class of cases indicated often exercises a slight but specific sedative influence.

Iodoform, which has come into such general use during the present decade, has in many cases proved very effective as a local anæsthetic, one of the chief barriers to its usefulness in dental practice being its penetrating, persistent, and unpleasant odor, and an insolubility so great that even ether and chloroform dissolve it but sparingly. Its odor it is impossible to entirely disguise; it may, however, be modified by the addition of the various aromatic oils. To ensure the contact with tissue to be medicated of a definite amount of the drug, its intimate mechanical admixture with other solids has been resorted to, as in the following formula:

℞. Iodoformi (pulv.),
Kaolin. (pulv.), *āā*, gr. ix;
Acidi carbolici (crystals), gr. viij.

Mix and add enough glycerin to form a paste, then add—

Olei menth. pip. gtt. x.

Signa. Place a small portion of the mass upon the exposed surface, using either the point of a probe or a pledget of cotton as the carrier; then carefully seal the cavity.

As a deodorizing formula the following has been suggested:

Take of	Iodoform,	100 parts.
	Oil of peppermint,	5 "
	Oil of neroli,	1 "
	Oil of lemon,	2 "
	Tincture of benzoin,	2 "
	Acetic acid,	1 "

Powder the iodoform and thoroughly mix with the other ingredients. Transfer to a well-stoppered flask and keep for two days over a water-bath at a temperature of from 120° to 140° F. The aroma of the freshly-roasted coffee-berry is also very efficient in disguising the odor of iodoform, and a preparation known as caff-iodoform, of which coffee forms one of the constituents, is now much employed. It is prepared by reducing the coffee-berry to an impalpable powder and thoroughly combining it with the iodoform in the proportion of 50 per cent.

Whenever iodoform is placed in a tooth, the cavity should be sealed if practicable, as in some subjects the taste and odor produce nauseating and irritative effects.

Menthol, a peppermint camphor obtained in a crystalline form by the exposure of Chinese oil of peppermint to cold, has proved very effective

as an analgesic in pulp-irritations, and has also been thought to obtund pain in sensitive dentine. As it is a much more volatile substance than the officinal camphor, and readily melts at the temperature of the body, it may for either purpose be placed in substance in the affected tooth. Usually, however, it is used in solution, either in carbolic acid, creasote, the oil of cloves, or the oil of cajeput, it being freely soluble not only in these substances, but in all oils, fixed and volatile, and also in alcohol, chloroform, and ether. A good formula for dental purposes is as follows:

℞. Menthol. gr. v;
Olei caryophylli, f℥j. M.

As a local application for neuralgia the following combination will often be found effective:

℞. Menthol. gr. v;
Olei cajuputi, f℥j. M.

S. Apply with a camel's-hair pencil to the seat of pain.

Menthol in substance rubbed over neuralgic areas is now a frequent form of medication, and is one among the many popular remedies for headache, having too, like other "cures," its share of successes. As menthol when swallowed often excites considerable nausea and gastric irritation, care should be exercised in its use in the mouth.

Cocaine.—Although infusions and other preparations of coca-leaves have for some years been used for diminishing the irritability of the pharynx and larynx, it was not until the publication, in 1884, by Koller, of his discovery that a solution of the alkaloid applied to the eye would locally anæsthetize the conjunctival and corneal surfaces of that organ, that public attention was called to the great value of the drug in general medical and surgical practice. Although so recently introduced, cocaine has already secured its place as easily chief of all known local anæsthetics; and while in dental surgery the results obtained from it have not been nearly so uniform or satisfactory as in other departments of the healing art, still its great value has been fully demonstrated, and further experience in its preparation and use will doubtless do much toward overcoming the obstacles which at present, in many instances, prevent the full development of its physiological effects.

Owing to the importance of this agent, the following facts concerning its history and preparation are here given:

Cocaine is an alkaloid obtained from the leaves of *Erythroxylon coca*, a plant cultivated in Peru, Colombia, and Bolivia on the slopes of the Andes, and which has long been in almost universal use among the aborigines as a tonic and stimulant, the Indians claiming that by chewing the leaves their physical powers are greatly increased, so that they are enabled to endure great bodily exertion with comparatively little exhaustion or fatigue. The term "erythroxylon" refers to the red color of the wood of some of the plants of the genus, while the word "coca" is said to be derived from the Indian word *khoka*, signifying the plant or shrub.

A writer in the *London Lancet*[1] gives the following description of the plant:

[1] December 13, 1884.

"The coca-shrub grows to a height of from four to eight feet, and resembles our blackthorn in appearance. It has small white, short-stalked, drooping flowers, in clusters upon the branches in places where the leaves have fallen. The leaves are closely placed, alternate, about two inches long, oval oblong, entire at the margin; sometimes they are acute, but usually blunt and emarginate, with a small apiculus in the notch at the apex, rather thin, but opaque, smooth with a prominent midrib, and on each side a curved line running from the base to the apex, showing its mode of venation. When fresh the upper surface is bright dark-green in color; the lower is paler and strongly marked with veins. The carefully dried leaves have the odor of tea, but if dried less perfectly they have a bouquet of their own, which is very unpleasant in the breath of those who chew it. They have a somewhat aromatic and bitter taste, and are more active when freshly dried. By permission we have tasted a fresh leaf in the Botanic Gardens, and the benumbing effect on the tongue, dulling its sensibility, was apparently much greater than that of a number of dried leaves. The plants are raised from seeds, and the cultivation, at an elevation of from two thousand to seven thousand feet above the sea-level, is carried on with great care. Five years are required for the full growth; the first crop of leaves is gathered at the end of a year and a half."

The alkaloid was first isolated from the leaves in 1855 by Gardeke, who called it erythroxylin. In 1860, Dr. Niemann made a thorough study of the plant and gave to the alkaloid the name, cocaine, by which it is now known. According to Lossen, its chemical composition is $C_{17}H_{21}NO_4$. Its crystallization is in monoclinic prisms, and 704 parts of water are required to dissolve it. In alcohol and ether it is more readily soluble. The taste of cocaine is bitter and its reaction strongly alkaline.

Hitherto, the cocaine hydrochlorate has been the salt most experimented with, but the citrate, salicylate, borate, oleate, and hydrobromate, as well as other salts, have been introduced with results which, while more or less satisfactory, are as yet not conclusive as to their relative value. In dentistry the hydrochlorate in aqueous solution, the strength varying from 2 to 10 per cent., has been chiefly used, the best average results having been obtained with a solution of 4 per cent.

Cocaine hydrochlorate is soluble, not only in water, but also in alcohol, ether, chloroform, glycerin, the volatile oils, etc. The following formula will give a 4 per cent. solution in water:

Take of Cocaine hydrochlorate, $2\frac{1}{4}$ grains;
Distilled water, f℥j. Mix.

The fact that the aqueous solution of cocaine is liable to deteriorate when kept for any considerable length of time has been no inconsiderable barrier to its successful employment, many cases of failure being doubtless due to this fact. The use of various preservative agents has been recommended, such as the substitution for pure water of distilled water containing seven grains to the pint of either thymol or salicylic acid. Camphor-water has also been successfully tried. As the result of numerous experiments with these agents during a period of six months a writer in the *Ephemeris* (May, 1885) affirms the "strong probability" that boric acid in the proportion of one-half of 1 per cent. will protect cocaine solutions until they are used up in ordinary

practice. The best results, however, are obtained when fresh solutions are made for each application or for use during each day. By making suitable subdivisions of a grain of the drug, and dropping upon the quantity selected the required proportions of water, using a graduated minim pipette for the measurement, very small amounts of a definitely proportioned solution can be obtained, and thus both waste and deterioration be avoided.

Physiological Effects.—Taken internally in large doses, cocaine may cause gastric irritation, this, however, being temporary in character, as local anæsthesia of the mucous lining of the stomach speedily ensues; to which influence is probably attributable the absence of the sense of hunger experienced by those who chew the leaves. The introduction of moderate amounts of the drug into the system is followed by increased action of the heart and quickening of the respiratory movements, the temperature being at the same time increased. In large doses, however, the action upon the circulation and respiration is depressant, paralysis of the lungs ensuing and the movements of the heart being arrested in diastole (Riggs). Both the motor and sensory nerves are depressed, but the sensory system chiefly and primarily. To the latter influence is due its anæsthetic effect upon all vascular surfaces with which it is brought into local contact, this being especially marked in the eye, both the conjunctiva and cornea being made insensitive to touch within a few minutes after the application of the drug, the effect continuing during half an hour. Marked mydriasis also results, the dilatation of the pupil frequently continuing during several hours, and being attended by uncertainty of vision and interference with the power of accommodation. A notable effect is upon the capillary blood-vessels, which are caused to contract. For this reason cocaine has been found a valuable hæmostatic; and even though the observation of Moore be correct, that contraction of the blood-vessels is, within twenty-five minutes, followed by a dilatation greater than their original calibre, still even a temporary contraction is of value, in that it favors the formation of clot.

Application of Cocaine in Dental Practice.—As has been intimated, the use of cocaine in dentistry has been successful only in a limited degree, the percentage of failures, especially in the treatment of sensitive dentine, being very large—a result sufficiently accounted for by the dense and relatively impermeable character of tooth-structure, and the consequent difficulty of securing with the anæsthetic agent a degree of saturation of the contents of the tubuli sufficient to obtund sensation. Contrary to reasonable expectation, this difficulty does not appear to be lessened in the case of young children, whose teeth, being less dense than those of adults, might therefore be assumed to be more permeable, whereas in point of fact better average results can be obtained with adults than with the very young. The writer's experience leads him to attribute this result to extraneous conditions, such as the great nervous excitability of the subject, and, as an indirect consequence, the difficulty of effectually removing débris, softened dentine, etc. from the carious cavity before applying the solution; while a third factor may be found in the profuse salivary outflow which in this class of cases so soon floods

the mouth, and of necessity rapidly lessens the strength of the anæsthetic application unless the latter be protected by the use of the rubber dam.

Another circumstance demanding attention at this point is the fact that the use of the rubber dam as a means for the protection of the solution prevents rather than favors the anæsthetic power of the drug. This is the experience of the writer, and is confirmed by the observation both of Thompson and Raymond, each of whom has placed on record the results of extended and intelligent experimentation. Dr. Raymond[1] reports failure with but a single exception: he states that "the cavities of decay have been carefully dried, being protected by the rubber dam, and a solution of the salt varying in strength from 4 to 10 per cent. has been put in the cavity. After a lapse of from three to six minutes this was repeated. In some instances I have called into requisition the hot-air syringe. In only one case has there been any appreciable loss of sensation, except where the heat from the syringe was continued and the dentine so thoroughly dried as to check the circulation through the tubuli. . . . . I have tried no less than thirty cases by instillation in the mouths of as many persons without any apparent diminution of pain."

This result, corresponding to the experience of Dr. Thompson, is by him attributed to an interference with osmotic action by the contents of the tubuli, resulting from the absence of the salivary moisture, the dry dentine absorbing a portion of fluid from the solution, but "not sufficient to obtain the toxic, benumbing effects necessary to insensibility."

To the writer, however, it hardly seems probable that any considerable desiccation of tooth-structure can go on in immediate presence of an aqueous solution applied, as is usual, in liberal amount; and a more plausible explanation of the phenomenon would seem to be, either that the alkalinity of the saliva favors osmotic action through its greater affinity for the probably subacid contents of the tubuli in a carious tooth, or that the presence of the rubber dam, closely applied, shuts off entirely all action upon, or absorption through, the gum-tissue or the peridental membrane, whose exalted sensibility, either directly or by reflex irritation, is often no unimportant element in the production of the painful sensations experienced by the patient in, or referred by him to, the implicated tooth.

Whatever may be the truth as to theories, the fact remains that the best success is obtained by applications made directly to the unprotected tooth. These it is generally necessary to renew from time to time. Dr. Thompson[2] recommends the following procedure: "Apply the 4 per cent. or 5 per cent. solution for twenty minutes. If not quiet, reapply for the same time, and repeat if not conquered. If not insensible then or nearly so, reapply for the same time, and repeat as often as may be necessary. If, after repeated applications, the pain cannot be controlled, you will of course acknowledge defeat. But there are very few cases which four or five applications of twenty minutes each will not conquer; usually two or three will suffice."

As is fully recognized by Dr. Thompson, this slowness of action con-

[1] *Dental Cosmos*, April, 1885. [2] *Ibid.*, June, 1885.

stitutes an almost insuperable barrier to the practical usefulness of the drug in every-day office routine. When such prolonged periods of time can be spared by patient and operator quite as good average results will be obtained in cases of sensitive dentine by the thorough drying of the cavity and its exposure, protected by the rubber dam, to the desiccating effects of ordinary atmospheric air, under which conditions the abstraction of moisture from the tubuli, and the consequent inhibition of functional activity on the part of their protoplasmic contents, will be so gradual as to occasion but little if any suffering. The same result can be much more rapidly attained by Dr. Register's process of throwing into the carious cavity from a storage-reservoir a steady current of air warmed to the body temperature.

Similar results are often sought for by the use of substances, such as absolute alcohol, tannin, mineral acids, zinc chloride, etc., having a strong affinity for water and at the same time producing coagulation of the albuminoid constituents of organic matter. These applications are, however, usually superficial in their action, and are often intensely painful.

The use of arsenious acid, the most potent of the pain-obtunders belonging to the escharotic group, is as a rule entirely inadmissible, owing to the pulp-devitalization which almost invariably follows its employment.

The unsatisfactory character of the results obtained by the use of cocaine as a direct local application has led Dr. Raymond and others to produce dental anæsthesia by the direct application of the agent to the main branches of the nerves supplying them with sensation. Dr. Raymond gives reports of several cases coming under his observation, one of which is the following:[1]

"Dr. W——; cavity on the posterior surface of the right inferior first molar; excessive sensibility on touching it. Caries had not caused much loss of the dentine covering the pulp. That organ was well protected and in a normal condition. The syringe was charged with thirteen minims of a 4 per cent. solution of cocaine, and the needle-point directed on a line extending about midway between the angle and the coronoid process of the inferior maxillary, passing through the internal pterygoid muscle. The finger being placed upon the internal oblique line as a guide, the syringe needle was carried along the inner surface of the ramus until it reached the nerve as it enters the inferior dental foramen. A 'tingling' sensation was produced in the bicuspids and incisors when the syringe was discharged. In three minutes the tongue began to feel numb and thick on the right side. In seven minutes there was almost complete anæsthesia of the right half of the tongue and the gums around the inferior teeth. The excavator being applied to the cavity, which was previously so tender, no sensation whatever was felt by the patient. I then used the engine with perfect freedom, and prepared the cavity for filling without any discomfort to him. Although there was just a slight degree of sensibility in the bottom of the cavity, he said it amounted to nothing comparatively; he was just conscious that the instrument was there. The gustatory nerve, which lies near the inferior dental at the point injected, accounts for the tongue being anæsthetized. As the gustatory was not touched, this shows that it

[1] *Dental Cosmos*, April, 1885.

is not necessary for the needle to penetrate the nerve-substance. The cervical portion of the cuspid on the left side was very painful to touch, owing to the denudation of the soft tissues that covered it; but while operating on the side injected the cuspid, although being in the same condition as the other, could be rubbed with a steel instrument without the slightest manifestation of pain. The anæsthesia lasted for about twenty-eight minutes, when normal sensibility returned. That evening, at dinner, there was some stiffness and a slight soreness in the muscles while masticating on the right side. The next morning there were no symptoms indicating that he had submitted to any unusual treatment."

Dr. R. J. Hall of New York gives the following report of the local anæsthesia of the superior maxillary nerve practised upon his own person:[1]

"This afternoon, having occasion to have the left first upper incisor tooth filled, and finding that the dentine was extremely sensitive, I induced Dr. Nash of 31 West Thirty-first street to try the effects of cocaine. The needle was passed through the mucous membrane of the mouth to a point as close as possible to the infraorbital foramen, and eight minims were injected. In two minutes there was complete anæsthesia of the left half of the upper lip and of the cheek somewhat beyond the angle of the mouth (as I was in the dentist's chair, I could not determine the exact limits), involving both the cutaneous and mucous surfaces; also of the left side of the lower border of the septum nasi and of the anterior surface and lower border of the gums, extending from the median line to the first molar tooth. Forcing the teeth apart with a wedge caused no pain except when the wedge impinged on the unaffected mucous membrane of the posterior surface of the gums. Dr. Nash was then able to scrape out the cavity in the tooth, which had previously been so exquisitely sensitive, and to fill it, without my experiencing any sensation whatever. The anæsthesia was complete until twenty-six minutes after the injection, and sensibility was much diminished for ten or fifteen minutes longer. Piercing the mucous membrane with the needle caused pain like the prick of a pin, but its subsequent introduction until it struck the bone, and the injection of the solution, were not felt. . . . In the experiment upon the teeth it surprised me that the incisor tooth should be rendered insensitive, as the antero-superior dental nerve is given off in the infraorbital canal. I can only suppose that the effect extends some distance along the nerve centrally, or that the fluid travelled along the sheath of the nerve into the canal."

Dr. Raymond's directions as to the method of preparing and using cocaine in this manner are as follows:

"The only way to get good results with the cocaine is to obtain a quantity of the soluble alkaloid and mix it at the time of using it. The requisites are a minim glass, a pair of scales, some filtering-paper, and a little water that has been boiled. It is necessary to have an easy-working syringe, with a perfectly smooth, sharp needle. Care must be taken to exhaust the air from the syringe when charged ready for use. This can be done by drawing in more of the solution than is needed, and pressing it out to the required number of minims. Hold the needle-point up, so as to allow the air to get above the solution; then press the piston."

While the experiments above recorded are exceedingly interesting

[1] *New York Medical Journal*, Dec. 6, 1884.

from the physiological standpoint, and while they testify to the skill and courage of the operators, still the writer ventures the opinion that in view of the possible consequences of this method of applying cocaine, such as the perforation of arteries or veins, injury to nerve-tissue, etc., the cases in actual practice are very rare in which its employment can be considered justifiable or expedient, and in which it would not be much better to give moderate doses of the safer of the general anæsthetics, as, for example, nitrous oxide gas, a few inspirations of which will speedily produce an analgesic effect upon the most sensitive teeth, and without the abolition of consciousness. While it is true that the duration of the influence is short, still it usually suffices for a rapid operator to accomplish the more painful details necessary in the preparation of the tooth; if not, additional doses can be given from time to time as may be needed. As a local anæsthetic in tooth-extraction cocaine has been found too superficial in its action to give satisfactory results. By deeply injecting it into the gum-tissues around the tooth to be extracted, however, a decided mitigation of the pain may sometimes be secured.

The Herbst Obtundent.—What is now known as the Herbst obtundent consists of a saturated solution of cocaine hydrochlorate in chemically pure sulphuric acid, to which solution sulphuric ether is added to the point of saturation, all excess of ether floating upon the surface and evaporating. According to Harlan, seventy grains of cocaine hydrochlorate are required to saturate two drachms of the acid. Even with this preparation, however, several applications are required before anæsthetic effects are developed.

Prof. Harlan[1] recommends a solution of cocaine hydrochlorate, ten grains in ninety minims of sulphuric ether, and states that applied to an exposed pulp for four or five minutes its painless extirpation can be accomplished.

Kava-kava Resin.—This substance is obtained from the root of the *Piper methysticum*, a shrub found in the Sandwich Islands, *kava-kava* being the native name for the root of the plant. Dr. Lewin was the first to call attention to the local anæsthetic power of this resinous extract; hence the name "Lewinin" has been proposed for it. Taken into the mouth, it is found to produce numbness, tingling, and finally local insensibility, accompanied by some pallor of the mucous membrane. Applied to the eye, it will produce complete insensibility of the conjunctiva and cornea. It is, however, too irritant in its effects to be employed in ophthalmic practice. Dr. Harrison Allen has derived very satisfactory results from the application of a 50 per cent. alcoholic solution to oral and naso-pharyngeal surfaces. Its usefulness in dental practice has not been determined.

Drumine.—Concerning this new claimant for place in the list of local anæsthetics, the following account is given in the *British Medical Journal*, January 1, 1887:

"An alkaloid has lately been obtained from the plant, *Euphorbia Drummondii*, N. O. Euphorbiaceæ, by Dr. John Reid of Port Germein, South Australia, which promises, if report be true, to compete with cocaine as an

[1] *Dental Review*, January, 1887.

agent for producing local anæsthesia. A tincture of the plant is made with rectified spirit or proof spirit acidulated with hydrochloric acid, and, after standing a few days, the spirit is distilled off, ammonia added in excess, and the whole filtered. The residue, after the smell of ammonia has disappeared, is dissolved in dilute hydrochloric acid, and filtered through animal charcoal to destroy the coloring matter, which is abundant and inactive. This filtrate is evaporated slowly and leaves the alkaloid. It gives a colorless solution with little taste. It is almost insoluble in ether, freely soluble in chloroform and water, and deposits from solution microscopic acicular and stellate crystals. The crystals deposited from the hydrochloric solution filtered through animal charcoal are circular or boat-shaped. They are colorless, and seem to be less soluble in chloroform. Sheep and cattle are stated to die in great numbers annually in consequence of having eaten this plant, the poisonous qualities of which vary in proportion to the quantity of milky juice present. Sheep, bullocks, and horses die in from twenty-four hours to seven days after eating it, all of them presenting paralysis of the extremities, some of them hanging the head as if tipsy; the appetite does not appear to be interfered with. It is curious that the animals avoid the weed at first, except under pressure of hunger, but, once having partaken of it, they seek for it and eat it with avidity. Injection of a solution of the alkaloid into the nostrils of a cat produced stupidity and indifference to stimuli, with a placid, stupid expression, like that of an animal under the influence of a narcotic. The limbs appeared paretic. A few drops of a 4 per cent. solution dropped into the eyes of another cat produced insensibility to the extent of allowing the conjunctiva to be touched, and the orbicular muscle no longer contracted with the same vigor. The pupil was not appreciably dilated. Three grains were then injected subcutaneously, but beyond local anæsthesia no effect was noted. A larger dose by the mouth promptly produced paralysis of the limbs and slow, difficult breathing. When dying strychnine was injected, but failed to produce any muscular contractions. Ten minims of the 4 per cent. solution injected into the hind leg of a cat seemed to produce paralysis of sensation, but not of motion. No convulsions ever followed its use. In the course of experiments on his own person Dr. Reid found that the drug produced anæsthesia, with loss of taste when applied to the tongue or nostril; but small doses swallowed were not followed by any perceptible constitutional symptoms. He tried it subcutaneously in a case of confirmed sciatica in an old man, and the essay was followed by complete and, so far, permanent relief; in sprains it was very useful in relieving the pain. Dr. Reid recommends the use of the alkaloid in small operations, local irritation, and sprains."

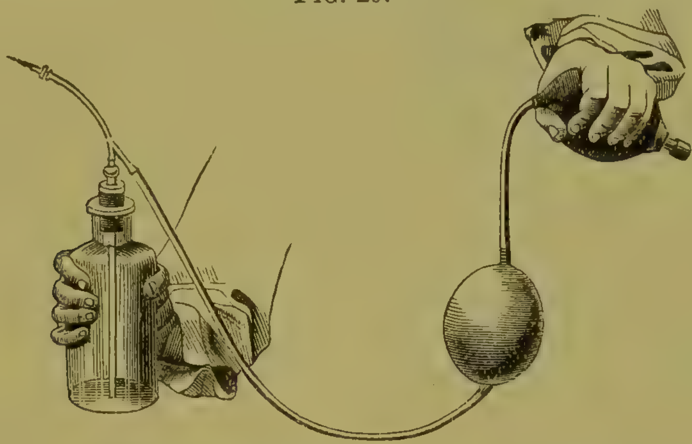
Local Anæsthesia by Freezing.—The first to suggest this process was Dr. B. W. Richardson, who in 1866 proposed the application of ether spray to the part to be incised, the rapid volatilization of the ether causing the abstraction of heat from the tissues to a degree sufficient to thoroughly freeze them. For this use it is necessary that the ether should be highly rectified, and, as far as possible, be absolutely free from either alcohol or water.

The use of rhigolene was subsequently introduced by Prof. Henry J. Bigelow, this fluid, owing to its greater volatility, producing frigorific effects even more rapidly than does ether. In dental practice, however, the results obtainable from rhigolene are not so uniformly satisfactory as with ether. With the latter agent the anæsthesia seems to be

more complete—a fact which is, in all probability, due rather to its systemic than its local effects, as when ether spray is thrown into the mouth the patient must inhale no inconsiderable amount of the vapor.

For the application of either of these agents in the extraction of teeth the atomizer represented in Fig. 29 is well adapted. Through a perforated cork in the bottle containing the ether passes a double tube, one extremity of the inner part of which is made long enough to reach to the bottom of the bottle. Above the cork a tube connected with the elastic bulb which forms the bellows pierces the outer part of the double tube, and communicates by a small aperture at the inner end of the cork with the interior of the bottle. The inner tube for delivering the ether runs upward to the extremity of the outer tube.

Fig. 29.



When the bellows are worked a double current of air is produced: one current, descending and pressing upon the ether, forces it along the inner tube; the other, ascending through the outer tube, plays upon the column of ether as it passes from the inner tube. In the figure the bulb compressed by the hand is the bellows bulb; the other serves as a storage reservoir, thus keeping up a steady pressure upon the ether and producing a continuous jet. A straight nozzle may be used when only a single jet is required, but for operations upon the teeth a double jet is usually desirable, the spray to be directed both upon the palatine and buccal or lingual surfaces of the gum-tissue. This can readily be accomplished by means of the double nozzle seen attached to the bottle in Fig. 30, another form being represented as in operation in Fig. 31. At *s* in the latter figure is shown an appliance devised by Dr. James E. Welch for pressing away the lip

Fig. 30.

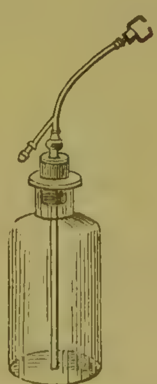
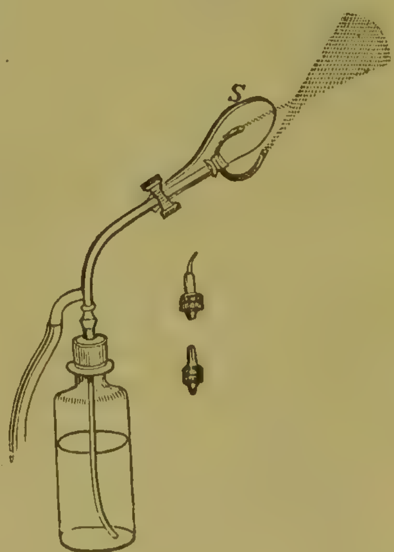


Fig. 31.



or cheek from the teeth to be operated upon, thus to a certain extent protecting it from the action of the spray.

Owing to the introduction of nitrous oxide the use of this method has been very generally abandoned, although it is still occasionally resorted to by some practitioners. There can be no question as to its efficiency in obtunding the pain incident to the actual extraction of a tooth, although it is often questionable whether the suffering occasioned by the freezing process and the reaction therefrom is not almost as great as would have been the extraction without anæsthesia. There is also frequently considerable difficulty in limiting the freezing process to a single tooth. No inconsiderable objection to the use of these agents is the penetrating odor which permeates the apartments in which they have been employed, as well as the clothing of the operator. Ether is especially obnoxious in this respect, the odor being very persistent.

As with other processes, the skill and experience which come from practice will do much toward overcoming the difficulties and disadvantages incident to their employment.

When a large, hollow, devitalized tooth is to be extracted, the root-investments can generally be sufficiently benumbed by throwing the spray into and upon the tooth itself, without impinging to any considerable extent upon the gum-tissues; and, although considerable time is necessary, this is by all means the most desirable method of securing local anæsthesia by cold in this class of operations. The method has this further advantage, that by placing around the tooth a sheet of rubber dam the non-conductivity of that material will to a great extent protect adjoining teeth from the action of the spray.

As a rule, however, the freezing must be accomplished through the gum and alveolar walls of the tooth. The pain incident to the first impact of the spray upon these surfaces is generally very great, especially in cases of pulp-irritation; but much can be done to modify this inconvenience by proceeding slowly with the process, and at first throwing upon the parts only small volumes of spray. Sensation may in this way be gradually and quite painlessly abolished, the spray being then thrown with more and more vigor until the parts are thoroughly frozen, as evidenced by the perfect blanching, the hardness, and the insensitiveness of the tissues. This is a condition of things readily recognized, as the gum becomes quite bloodless and white.

When this process has been carried far enough, the extraction of a tooth is rarely attended by actual pain, although as long as consciousness lasts the sensation can never be otherwise than one of discomfort. The reaction, however, is always painful, and frequently intensely so. This can be in a measure obviated by applications of ice or of ice-water to the parts, so as to make the process more gradual.

The application of the freezing process to the lower teeth is frequently attended with difficulty, owing to profuse salivary outflow: this source of embarrassment can best be overcome by the use of a saliva ejector. The tongue should be held away from the tooth to be operated upon by a suitable depressor, between which and the tongue a napkin should be placed for the further protection of that organ against the action of the

spray. Both in the upper and lower jaw the tissues of the cheek should be carefully shielded by analogous means or by the shield shown in Fig. 30.

Although sloughing is one of the dangers of the freezing process, the possibility of which should always be borne in mind, it has rarely occurred in dental practice, the great vascularity of the parts and the limited area operated upon serving as a safeguard against this untoward result. The accident is far more likely to occur in those cases in general surgery where extended surfaces are frozen to a hardness so great as to render cutting with the knife a matter of such difficulty as to compel the use of strong curved scissors—a substitution suggested by Dr. Richardson.

As a substitute for ether or rhigolene spray Mr. James Arnott of London has suggested the employment of freezing mixtures, of which the most convenient is the well-known mixture of ice or snow and common salt, the rapid liquefaction of which when in contact causes the abstraction of heat from the surfaces upon which the mixture rests. The proportions which secure the best results are two parts of crushed ice and one part of salt. These should be thoroughly mixed and placed in a bag of gauze or other thin fabric through which the water can drain as rapidly as it is formed—a condition greatly favoring success—and then applied to the part to be frozen. This method has been employed in dental practice, and by making bags of suitable size, and having the ice and salt finely pulverized, successful results can be obtained. In making bags for this purpose the side to be placed next the cheek or tongue should be covered with sheet rubber, for the protection of those parts from the action of the cold. As the taste of the brine is exceedingly disagreeable, a soft napkin should be placed upon the tongue to receive the liquid as it falls from around the tooth; in the lower jaw the saliva ejector can be employed. Bags made of bladder tissue may be used, but as these confine the water as it is formed, they are not so effective, although in the mouth the absence of dripping is certainly a convenience.

The following account, given by Dr. Cheize,[1] of a simple and successful method of obtaining local anæsthesia with ether is not without interest, inasmuch as the process might, in an emergency, be applied in dental practice:

"Several days ago a young girl presented herself with an ingrowing toe-nail, which she desired to have removed immediately, as she resided at a considerable distance. Richardson's apparatus not being available, I replaced it after the following fashion:

"I wet with ether a piece of wadding of about the size of a five-franc piece: this I placed upon the great toe, and with a chimney bellows blew a current of air upon the ether. In two minutes the evaporation was complete. I moistened the wadding a second time and evaporated as before. I then removed the ingrowing nail, and cauterized with a red-hot iron the internal border of the matrix without the slightest perception upon the part of the patient. I was obliged to show her the nail to convince her that the operation had been performed."

[1] See *Revue Odontologique de Bruxelles*, June, 1884.

ELECTRICITY.—Electricity is one of the many agencies which have been experimented with as pain-obtunders in tooth-extraction, both the galvanic and faradic currents having been employed and by several methods of application. Dr. J. O. Scott[1] states that he has employed the following method "with fair success:"

"Use a Kidder electro-magnetic machine, or any other giving very rapid vibrations of armature. Place the positive electrode on the gum of the tooth to be extracted, and the negative in the patient's hand or at the back of the neck. Start with a light current, and gradually increase the strength as much as can be borne without producing pain. The electrode applied to the tooth should embrace each side, the better to convey the current. For this purpose it should be bifurcated at the end of the handle, the arms of sufficient length for convenience in operating. At the ends of these solder small disks about the size of a dime. The handle and arms must be insulated, to prevent the current passing off at any other point than the disks. Cover the disks with thick pads of fine sponge. A cylinder electrode, also covered with sponge or cloth, is the proper one for the hand. Moisten each with saline water."

Another method was to attach one pole of the battery to the extracting forceps, the handles of which were carefully insulated, the other being held in the hand of the patient. Contact of the forceps with the tissues around the tooth of course closed the circuit, with the effect, usually, of giving an added pang to an already sufficiently painful process.

Concerning the general efficacy of this method the conclusions embodied in the following report of a committee of the College of Dentists, England, remain unquestioned:[2]

"The committee have in their possession the records of sixty-eight cases of tooth-extraction, in sixty-five of which the anæsthetic value of electricity was tested with all the care and the knowledge at the command of the observers. Fifty-five of these operations were performed to test the value of the intermittent current; ten were performed to test the value of the continuous current. In these experiments every possible modification was introduced. The poles of the battery were reversed in different cases; the force of the current, as indicated by the sensation of the patients, was varied; and every necessary precaution was taken to secure insulation of the operator.

"The committee, in viewing the whole of the results of the experiments thus performed, find that in much the larger proportion of cases the results were purely negative. In several instances more pain was excited, owing to the application of the current, than if the tooth had been removed at once by simple extraction, in other instances less, while in a few cases, amounting to five altogether, there was evidence of relief. In three instances this evidence was well marked.

"The committee does not, however, put forth these latter five named cases as instances of local anæsthesia. It appears to the committee that in all instances where success was apparent a mental element was called into action, and the patients at the time of the operation were in a state of partial general insensibility, due probably to hysterical syncope.

[1] See *Dental Cosmos*, May, 1881. [2] *Ibid.*, October, 1859.

"In those examples where the patients expressed that the pain was less than they had experienced on previous occasions, the assumed relief did not arise from the fact that the tooth and its neighboring parts had been rendered dead to external impressions, but from various extraneous causes, of which the committee may enumerate as the most prominent—

"1. Diversion of sensation;

"2. Less difficulty in extraction as compared with other extractions;

"3. Syncope more or less marked;

"4. Differences in method of operating.

"On one final point the committee is unanimous: that in not one instance did any member observe the merest approach to local anæsthesia."

Voltaic Narcotism.—This term was applied by Dr. Richardson of London to his plan of local anæsthesia by the action of a galvanic current passing through a narcotic solution held in contact with the part to be operated upon, Dr. Richardson's claim being that under this influence narcotic substances passed much more readily into the tissues, and that in many instances complete local anæsthesia was in this way produced by solutions which were entirely inert when applied, even to the most delicate tissues, without the galvanic current.

In reference to the application of this plan to dental surgery the above-named committee report[1] that by the application of a narcotic solution to a tooth in connection with a continuous current of electricity of considerabte intensity, the pain of extraction is in some instances entirely broken, but that the process "can be used successfully only in cases where the cavity of the tooth is exposed." Dr. Richardson's plan never passed beyond the experimental stage, and the general verdict was, and remains, that any true anæsthetic influence produced by the method was due simply to the absorption of narcotic agents, upon the rate and efficacy of which process galvanism exercised no direct influence.

Rapid Breathing.—This method of obtaining a transient analgesic influence was first suggested by Dr. W. G. A. Bonwill of Philadelphia, whose presentation of the merits of his discovery is here reproduced:[2]

"I can produce, from rapidly breathing common air at the rate of one hundred respirations a minute, a similar effect to that from ether, chloroform, and nitrous oxide gas in their primary stages; and I can in this way render patients sufficiently insensible to acute pain from any operation where the time consumed is not over from twenty to thirty seconds. While the special senses are in partial action the sense of pain is obtunded, and in many cases completely annulled, consciousness and general sensibility being preserved.

"To accomplish this, each patient must be instructed how to act and what to expeect. As simple as it may seem, there is a proper and consistent plan to enable you to reach full success. Before the patient commences to inhale he is informed of the fact that, while he will be unconscious of pain, he will know full or partially well every touch upon the person; that the inhalation must be vigorously kept up during the whole operation, without

[1] *Op cit.*

[2] "Rapid Breathing as a Pain-Obtunder," etc., by W. G. A. Bonwill, D. D. S., read before the Philadelphia County Medical Society, May 12, 1880; published in the *Scientific American Supplement*, No. 275, April 9, 1881.

for an instant stopping; that the more energetically and steadily he breathes the more perfect the effect; and that if he ceases breathing during the operation pain will be felt. Fully impress patients with this idea, for the very good reason that they may stop when in the midst of an operation and the fullest effects be lost. It is obligatory to do so on account of its evanescent effects, which demand that the patient be pushed by the operator's own energetic appeals to 'go on.' It is very difficult for any person to respire more than one hundred times to the minute, as he will become by that time so exhausted as not to be able to breathe at all, as is evidenced by all who have thus followed my directions. For the next minute following the completion of the operation the subject will not breathe more than once or twice. Very few have force enough left to raise hand or foot. The voluntary muscles have nearly all been subjugated and overcome by the undue effort at forced inhalation of one hundred over seventeen, the normal standard.

"The heart's action is not increased more than from seventy (the average) to eighty, and sometimes ninety, but is much enfeebled or throwing a lesser quantity of blood. The face becomes suffused, as in blowing a fire or in stooping, which continues until the breathing is suspended, when the face becomes paler. (Have not noticed any purple, as from asphyxia by a deprivation of oxygen.) The vision becomes darkened, and a giddiness soon appears. The voluntary muscles farthest from the heart seem first to be affected, and the feet and hands, particularly the latter, have a numbness at their extremities which increases, until in many cases there is partial paralysis as far as the elbow, while the limbs become fixed. The hands are so thoroughly affected that when open the patient is powerless to close them, and *vice versâ*. There is a vacant gaze from the eyes, and a looking into space without blinking of the eyelids for a minute or more. The head seems incapable of being held erect, and there is no movement of the arms or legs, as is usual when in great pain. There is no disposition on the part of the patient to take hold of the operator's hand or interfere with the operation."

Dr. Bonwill's theory of the action of rapid breathing in producing insensibility to pain is thus summed up:

"The *first* thing enlisted is the *diversion of the will-force* in the act of forced respiration at a moment when the heart and lungs have been in normal reciprocal action (twenty respirations to eighty pulsations); which act could not be made and carried up to one hundred respirations per minute without such concentrated effort that ordinary pain could make no impression upon the brain while this abstraction is kept up.

"*Second.* There is a specific effect resulting from enforced respiration of one hundred to the minute due to the *excess of carbonic acid gas set free from the tissues*, generated by this enforced normal act of throwing into the lungs *five times* the normal amount of oxygen demanded in one minute, when the heart has not been aroused to exalted action, which comes from violent exercise in running or where one is suddenly startled; which excess of carbonic acid cannot escape in the same ratio from the lungs, since the heart does not respond to the proportionate overaction of the lungs.

"*Third.* Hyperæmia is the last in this chain of effects, which is due to the excessive amount of air passing into the lungs, preventing but little more than the normal quantity of blood from passing from the heart into the arterial circulation, but damming it up in the brain, as well as through-

out the capillary and venous system, and as well upon the heart, the same as if it were suspended in that gas outside the body."

Dr. Addinell Hewson of Philadelphia, who has extensively and successfully employed the rapid-breathing process in minor surgical operations, gives the following account of the phenomena incident to the process as he has observed them:

"The first effect of this breathing appreciable to an observer is a change in the color of the face: the lips, the cheeks, and the tint of the face, at first brightened, generally become pallid, then leaden or bluish; and with these latter changes the expression is altered and wanting in animation. If the eyes are open, they have a vacant look, and the lids begin to droop; the patient assumes the look of one much overcome by fatigue, and then of one on the verge of an ordinary sleep. Then often ensues, especially in an hysterical young girl, a state of very positive muscular rigidity: before this, however, ensues, the state of analgesia has been brought about, and is indicated by the want of recognition of the prickings of pins or the like, for the patient will always feel the abrupt contact of obtuse bodies, even the touch of your hand, but will not now experience any pain even from a bistoury or scalpel. The state of rigidity which I have just referred to resembles much that of catalepsy and what is frequently noticeable in cases where anæsthetics are being administered. The power to move is embarrassed by this; the will, however, would seem to have persisted, as the patients tell you afterward, and may even show you during this state by their efforts, without full ability, to follow your directions in moving or suffering you to move a limb. This rigidity of the muscular system is by no means of constant occurrence; it is often very slight and transient and gives way. It is clearly from the semi-asphyxiated state induced by the patient's breathing, for on ceasing to urge on him the rapid rate, he relapses into a quiet normal rate, and so, soon allowing his blood to recover from its intensely purple hue, he comes out of this state, and gradually recovers his ability to appreciate and remember the contact of foreign bodies and to move away from them.

"The subjective phenomena of this process are, as far as they go, essentially like those from nitrous oxide, ether, and even chloroform. There is first the swimming or confusion in the head and the loss of perfect or acute consciousness, attended with a sensation of tingling and distension of the surface; this latter beginning at the sentient extremities, and the hands especially, and passing upward; and closely following these sensations comes the condition of analgesia, absence of appreciation of painful impressions on those sentient nerves. . . . .

"Every circumstance would therefore seem to indicate that this process of inducing insensibility to pain is one essentially of diminished oxidation and decarbonization of the blood, and, recognizing such a state as belonging to the initiative stage of all anæsthetics when *insensibility to pain* is positively marked, we have no necessity for begging any special theory for this process, as in its action it readily comes under the category of such agents, and is thus not either an *absurdity* or an impossibility from a scientific point of view."[1]

It will be observed that while Dr. Bonwill and Dr. Hewson perfectly

[1] "Some Comments on the History of Nitrous Oxide Gas as an Anæsthetic, and on the Analgesic Effects of Rapid Breathing," by Addinell Hewson, M. D. From the *Trans. International Medical Congress*, Philadelphia, 1876.

agree as to the efficacy of the process, they radically differ as to the nature of the physiological changes in the nervous, respiratory, and circulatory systems produced during its progress. Further investigation upon these points would seem to be needed, as none of the theories yet advanced fully and satisfactorily explain the phenomena in question.

The process itself has as yet come into but limited use, although Dr. Bonwill in his own practice (dental) uses it to the exclusion of all other agencies.

For the production of satisfactory results the method would appear to demand from the patient a violence of exertion of which many are quite incapable, and which is not without its dangers for aged persons or for those affected with cardiac lesions or with structural degeneracy of the arterial walls, or in whom there exist pathological conditions of the respiratory tract.

If, however, by the judicious practice of this method an expectancy of painlessness can be secured, and the courage of the patient be thus so fortified that he will consent to the performance of slight operations without resort to general anæsthesia, a great good will have been accomplished, even though the expectancy should prove more or less illusory.

As regards the extraction of teeth, the fact must be remembered that, when skilfully accomplished, the operation, while never agreeable, is in a considerable percentage of cases almost painless. In such cases at least the operator should discourage the use of anæsthetics and adopt any legitimate method to induce his patient to submit to the operation without their aid. In that vastly greater class of cases, however, in which it is certain that for the patient in the normal state the suffering incident to the surgical procedure will be very severe, simple humanity demands the adoption of alleviatory measures; and of these analgesia by rapid breathing is not likely soon or readily to supplant the use either of local anæsthetics or of agents which swiftly and surely bestow not only absolute painlessness but oblivion.

PART II.

PHYSIOLOGY OF DIGESTION, VOICE AND SPEECH.

PHYSIOLOGY OF DIGESTION.

By ALBERT P. BRUBAKER, A. M., M. D., D. D. S.

The function of digestion is the first step in the nutritive process, and includes a long series of physical and chemical processes by which the various articles of the food, introduced into the alimentary canal, are transformed into new substances capable of being absorbed into the blood. The alimentary substances which are required daily by the organism for the repair of its waste and for the evolution of heat and force are seldom in such a condition that they can at once pass into the blood and be assimilated. They therefore must be changed physically and chemically before they can be absorbed into the blood, assimilated by it, and become constituent parts of the body. These changes are mainly accomplished by the admixture of the food with the different solvent fluids which are secreted by the glandular apparatus in connection with the alimentary canal.

Each article of food is a heterogeneous compound consisting of inorganic, organic non-nitrogenized (amylaceous and oleaginous), and organic nitrogenized (albuminous) principles, combined with a varying proportion of innutritious material. When subjected to the solvent action of the digestive fluids the food undergoes disintegration, and the alimentary principles, freed from their combinations, are converted into compounds capable of absorption and assimilation. The inorganic alimentary principles, retaining the same specific characters in the solids and fluids of the body that they do in the different articles of the food, do not undergo any transformation by the digestive fluids, but are at once, as such, taken up by the blood and become more or less important elements in its chemical composition. The organic principles, however, are generally associated with materials possessing but slight nutritive value, from which they must be separated before they can be converted into absorbable compounds. This is accomplished by the disintegrating action of the digestive fluids. These fluids, penetrating the different articles of the food, liberate the nutritious principles by dissolving out the connective tissues with which they are associated. The amylaceous, oleaginous, and albuminous principles are then converted into new substances, which, while the food is passing downward through the alimentary canal, are absorbed into the blood, and the innutritious elements, mingled with various waste matters, are finally extruded from the body.

The digestive apparatus comprises the entire alimentary canal and its glandular appendages—viz. the salivary glands, the gastric and intes-

tinal glands, the liver, and the pancreas. The extent, complexity, and anatomical peculiarities of this apparatus are subject to remarkable variations in the different classes of animals, corresponding with the nature of the food upon which they live, being more highly specialized in the herbivorous than in the carnivorous animals. Though all portions of the digestive apparatus exhibit more or less diversity in their anatomical structure, yet this is especially seen in the conformation of the stomach. In the ruminating animals—*e. g.* camel, deer, sheep, etc.—which live upon an exclusively vegetable diet, the complexity of the stomach is very marked, it being divided into four distinct compartments. The œsophagus opens at a point midway between the first and second of these divisions. The first and largest of these compartments is termed the rumen or paunch, and acts as a temporary reservoir in which the imperfectly masticated food is retained for a varying length of time and made soluble by the fluid secreted by its walls. The second compartment is much smaller, and is known as the reticulum : its inner surface is divided by ridges into a number of hexagonal cells which are surrounded by muscular fibres and which are capable of containing a large quantity of water. After the food has lain in the paunch for a sufficient length of time, and has become incorporated with the fluid, it passes into the reticulum, where it is compressed into small pellets or balls, and at intervals is regurgitated into the mouth, where it is again masticated and incorporated with the saliva. It is then swallowed a second time, and, as it is in a soft, pulpy condition, it is directed into the third compartment, the omasum or "many-plies," the mucous lining of which is thrown into longitudinal folds resembling the leaves of a book. Thence it passes into the fourth compartment, the abomasum, or true stomach, in which the gastric juice is secreted and true digestion takes place. In the carnivorous animals, whose food is highly nutritious, this complexity of the stomach does not obtain, and it is relatively simple. When the food is easy of solution the stomach is merely a slight dilatation of the alimentary canal ; but when it is difficult of digestion, requiring a much longer time for its solution, the stomach increases in size and is directed transversely across the abdomen. The left extremity becomes dilated into a well-marked pouch, while in many instances a constriction almost completely separates the cardiac from the pyloric extremity. The small intestine in the two classes of animals exhibits similar differences in regard to its length, due chiefly to the character of the food upon which they exist. In the herbivorous animals, in which large quantities of food must be retained for a considerable length of time, owing to the small percentage of nutritious matter it contains, the intestine is frequently twenty-five times the length of the body. In the carnivorous animals, however, whose food is much less bulky, and in which the percentage of nutritious matter is much greater, the intestine is not more than four or five times the length of the body. In many of the herbivorous animals the termination of the small intestine, the cæcum, undergoes an enormous development, and plays the part of a secondary stomach in which a partial digestion and absorption takes place. It frequently attains a size many times larger than the stomach itself. This structure is especially well developed in the horse, rabbit, capybara, etc.

In man, whose food consists of both animal and vegetable matter containing but a relatively small percentage of innutritious matter, the digestive apparatus, in regard to the conformation of the stomach and length and capacity of the intestine, occupies an intermediate position between the two classes of animals, being neither so highly specialized as in the Herbivora nor so simple as in the Carnivora. The stomach is large and well developed, and the length of the alimentary canal from six to eight times the length of the body. The alimentary canal of man consists, first, of the mouth or buccal cavity, which opens posteriorly through the isthmus of the fauces into the pharynx. This division is followed by the œsophagus, a narrow tube about nine inches in length, which passes downward through the diaphragm and expands into the stomach. This organ is shaped somewhat like a bagpipe, and forms a temporary reservoir in which the food is retained until partially digested. It is followed by the small intestine, measuring about twenty feet in length and extending to the ileo-cæcal valve; it is quite narrow and very much convoluted for economy of space. In its upper portion are two orifices, which are the beginnings of the pancreatic and biliary ducts. The large intestine is from five to six feet in length, and extends from the ileo-cæcal valve to the anus. The alimentary canal is composed of (1) a muscular coat externally, the fibres of which are arranged longitudinally and circularly, and (2) a mucous coat internally, which in the stomach is thrown into longitudinal folds, and in the small intestine into transverse folds, forming the so-called "valvulæ conniventes."

The general process of digestion commences when the food is introduced into the mouth. It is there subjected to the mechanical disintegrating action of the teeth, and is thus prepared for the further action of the digestive fluids. While undergoing mastication the saliva that is being poured out by the parotid, submaxillary, and sublingual glands is being incorporated with the food, which has the effect of not only moistening it, and thus facilitating deglutition, but also of acting upon the starchy elements of the food and transforming them into dextrin and grape-sugar. When thoroughly masticated and saturated with the saliva the bolus thus formed is rapidly passed from the mouth through the pharynx and œsophagus into the stomach by the combined action of the muscles of the tongue and the constrictor muscles of the pharynx and œsophagus. The stomach is a reservoir formed by a dilatation of the alimentary canal, in which the food is retained for a varying length of time, and where it is subjected to the disintegrating and chemical action of the gastric juice. As a result, the various articles of food are transformed into a liquid condition, and the albuminous principles, under the influence of the organic ferment and free acid, are converted into peptones, which are soluble and highly diffusible forms of albumen. The acid reaction of the gastric juice retards at least the action of the salivary ferment, as it is only operative in the presence of an alkali. The oleaginous matters are not acted upon either by the saliva or the gastric juice. As soon as liquefaction has taken place the pyloric orifice, until then closed, gradually relaxes, and the digested mass passes into the small intestine when the digestive process reaches its period of

greatest activity. The food is then subjected to the action of the pancreatic, biliary, and intestinal secretions, all of which are decidedly alkaline in reaction. The conversion of the starchy elements, which was interfered with in the stomach, recommences with increased energy. The fatty matters are emulsionized by the pancreatic secretion and reduced to a state of minute division. The neutral fats and oils are split up into fatty acids and glycerin, the former uniting with the alkaline bases to form soaps. In addition, the pancreatic secretion supplements the action of the gastric juice and transforms the albumen into peptones. The bile is poured into the intestine most abundantly about two hours after a meal, just when the digested food passes from the stomach through the pyloric orifice. This fluid assists in the emulsification of the fats and promotes their absorption, prevents putrefactive changes in the food, and excites the normal peristaltic action by which the food is propelled onward through the intestine. The intestinal juice secreted by the follicles imbedded in the mucous membrane acts upon the starchy elements and transforms them into glucose. During this series of chemical changes the food is being carried from above downward by a progressive vermicular motion of the muscular coat of the intestine; at the same time, the nutritious portions, comprising the water and inorganic salts, the peptones, glucose, and fatty emulsion, are absorbed by the veins and lymphatics and carried into the blood. The innutritious and indigestible matter passes into the large intestine, from which it is extruded along with other waste matter as the feces.

Digestion may be conveniently divided into six stages—viz. Prehension, Mastication, Insalivation, Deglutition, Gastric Digestion, and Intestinal Digestion.

Prehension.

The prehension of the food is accomplished by the mouth and its appendages, the teeth, lips, and tongue. This stage of the digestive process is but slightly employed in the adult human subject, and is confined chiefly to the young child in the act of sucking. In the performance of this act the lips are placed around the nipple and the posterior portion of the mouth closed by the pendulous veil of the palate. The tongue is then drawn backward, which produces a slight vacuum in the anterior portion of the mouth, into which the milk is forced by the external pressure of the air upon the breast. In many of the lower animals the appendages to the mouth are highly developed and play an important part in the prehension of the food.

Mastication.

Mastication may be defined as the act by which the food is thoroughly triturated by means of the teeth and the movements of the lower jaw under the influence of muscular contraction. The complete mechanical disintegration of the food is most essential for the subsequent solution and chemical transformation which it is destined to undergo in the stomach and intestines; for when finely divided the

food presents a greater surface to the action of the digestive fluids, and enables them to exert their solvent and fermenting action to a more marked degree, thus facilitating their absorption into the blood. Imperfect mastication, the result either of defective teeth or of the injurious habit of eating too rapidly, and the consequent imperfect solution of the food in the stomach and intestines, is the most fertile cause in the production of primary indigestion and malassimilation. Under such circumstances the food remains in the alimentary canal for a long time; digestion becomes difficult and prolonged, and approximates that of the carnivorous animals, in which the act of mastication is reduced to a minimum. The more thoroughly the disintegration of the food in the mouth and its incorporation with the saliva are effected, the more readily will it be acted upon by the gastric and intestinal fluids, and be converted into those substances—viz. albuminose, glucose, and fatty emulsion—which are capable of being readily absorbed into and assimilated by the blood.

TEETH.—The teeth are the essential organs of mastication, for it is by their action that the food is divided and triturated, so that it can be readily penetrated by the digestive fluids and be more easily swallowed. In man passing from childhood to adult life two sets of teeth make their appearance: the first set constitutes the temporary, deciduous, or milk teeth; the second set constitutes the permanent teeth, which should last to an advanced age or through life.

The temporary teeth, twenty in number, ten in each jaw, though smaller than the permanent teeth, have the same general conformation. They are divided into four incisors, two canines or cuspids, and four molars for each jaw.

The permanent teeth, thirty-two in number, sixteen in each jaw, are divided into four incisors, two cuspids or canines, four bicuspids or premolars, and six molars.

Each tooth may be said to consist of three portions: 1, the crown, or that portion which projects above the gums; 2, the root or fang, which is imbedded in the alveolar socket; 3, the constricted portion or neck between the two, and which is surrounded by the free margin of the gum. The teeth are firmly imbedded in the alveolar processes of the jaws; their roots are covered by a periosteum which has the dual function of nourishing the surface of the root and the process surrounding it.[1]

From the tuberculated character of the grinding surface of the molar teeth they are pre-eminently the grinding or triturating organs of mastication. They are exceedingly well developed in the herbivorous animals, where from the nature of their food considerable grinding is required before it can be properly digested. The presence of these two classes of teeth in man—viz. incisors or cutting, molar or grinding teeth—enables him to partake of and masticate both kinds of food, animal and vegetable.

The curve of the dental arch in man is uniform and continuous, and not broken by any intervals or diastemma, as in some of the lower animals. The superior is wider than the inferior, and its teeth are

[1] For a description of each tooth see "Human Dentition," in article on "Comparative Anatomy of the Teeth," Vol. I., p. 437; and for tooth-structure see "Histology," Vol. I., p. 590. For eruption of teeth, see paper in this volume.

directed obliquely outward and forward, while in the inferior arch the teeth are inclined inward or are at least vertical, so that when the jaws are closed the upper teeth overlap the lower. When the jaws are closed it will be observed that the upper cuspids and bicuspids strike partly against the corresponding teeth of the lower jaw and partly against the one next following, while the cusps of the upper molars will strike the lower molars behind the corresponding cusps. This is caused by the larger development of the upper central incisor pushing the teeth outward.

Movements of the Lower Jaw.—The lower jaw presents a vertical or downward and upward, an anterior, a posterior, and a lateral or horizontal movement, all dependent upon the peculiar construction of the articulation of the condyle of the inferior maxillary with the temporal bone. The lower jaw resembles a horseshoe in shape. It is divisible into a horizontal portion, the superior border of which supports the alveolar process, in which are implanted the teeth, and a vertical portion, the ramus. The surfaces of the bone present numerous depressions and ridges, which serve for the attachment of the muscles employed in the act of mastication. The upper extremity of the ramus is surmounted by two processes, the coronoid and the condyloid, separated by the sigmoid notch. The coronoid process is conical in shape and gives attachment to the tendon of the temporal muscle. The condyle is convex on its upper surface and is compressed from before backward. Its long axis is directed from without inward and obliquely from before backward, and articulates with the glenoid cavity of the temporal bone. The superior maxillary bone plays but a passive part in the process of mastication, it being immovably attached to the bones of the face and head. Its lower border supports the alveolar process, in which are implanted the upper teeth, which form a fixed point against which the teeth of the lower jaw crush the food.

Temporo-maxillary Articulation.—This articulation is formed on either side by the anterior portion of the glenoid cavity, the eminentia articularis, and the condyle of the inferior maxilla, all of which are united together by means of ligaments. Situated between the glenoid cavity and the condyle is a plate of fibro-cartilage oval in shape and biconcave. This cartilage divides the joint into two cavities—one above, the other below—each of which is provided with a synovial membrane. The function of the cartilage is to constantly present an articulating surface to the condyle in the various movements of the lower jaw, which it is enabled to do from being freely movable.

In the downward movement of the lower jaw the condyles glide forward, carrying with them the interarticular fibro-cartilage, the upper concave surface of which is applied to the convex surface of the eminentia articularis. In the upward movement of the jaw both the condyles and cartilages pass backward and resume their normal position. These movements of depression and elevation are made possible by the transverse direction of the condyle. In the carnivorous animals, whose food requires considerable cutting and tearing, these two movements are especially well developed. In the antero-posterior movement the jaw moves in a horizontal direction and the condyles and articular carti-

lages glide forward and backward in the glenoid fossæ. In the rodent animals the long axis of the condyle runs in the antero-posterior direction, which allows of a considerable gliding movement. When the jaw performs a lateral movement the condyle and cartilage of one side remain in their normal position, while the opposite condyle and cartilage glide forward in the glenoid fossa, directing the symphysis of the jaw to the opposite side of the median line. The lateral movements are well exhibited by the herbivorous animals, in which they are quite extensive, and made possible by the small size of the condyle and the large extent of articulating surface. In man the structure of the joint is such as to admit of all these movements, and the lower jaw acquires in consequence great mobility.

The movements of the lower jaw are caused by the action of numerous muscles, which, having a fixed point of origin, are attached to various points on its surface. The muscles concerned in the movements of mastication are presented in the following table:

Function of the Muscles of Mastication.

Anterior belly of digastric Mylo-hyoid Genio-hyoid Platysma myoides	Depress the lower jaw and open the mouth.
Temporal Internal portion of masseter Internal pterygoid	Elevate the lower jaw and close the mouth.
External pterygoids External portion of masseter Anterior fibres of temporal	Draw the lower jaw forward and cause the teeth to project beyond the upper.
Posterior fibres of the temporal Internal portion of masseter Digastric, mylo-hyoid, and genio-hyoid	Draw the lower jaw back to its normal position.
Internal pterygoids External pterygoids	Contracting alternately, draw the jaw to either side.
Pteryoids, external and internal Temporal Masseter	Produce grinding movements of the lower jaw.

Depressor Muscles of the Lower Jaw.—The *digastric* muscle, as its name implies, consists of two fleshy portions, an anterior and posterior, united together by a short rounded tendon. The posterior portion arises from the under surface of the mastoid process, and thence passes downward and forward to the hyoid bone; the anterior portion then passes upward and forward to be inserted into the lower border of jaw near the symphysis. Its central tendon pierces the stylo-hyoid muscle, and is firmly attached to the body of the hyoid bone by a loop of fibrous tissue, through which it plays as in a pulley.

The *mylo-hyoid* muscle is broad and triangular in shape, and forms with its fellow of the opposite side the floor of the mouth. It arises from the mylo-hyoid ridge throughout its entire length and the internal surface of the inferior maxilla: its fibres then pass inward and backward to be connected in the median line with the fibrous raphé, and posteriorly with the body of the hyoid bone.

The *genio-hyoid* muscle, situated just within the preceding, is thin and flat in shape, and arises from the genial tubercles on either side of

the symphysis. Its fibres pass backward and downward to be inserted into the body of the hyoid bone.

The *platysma myoides* is a broad expansion of muscular fibres situated immediately beneath the skin on either side of the neck. Arising from the clavicle and acromion process, its fibres pass obliquely upward and forward, to be inserted mainly into the anterior part of the inferior maxilla.

The *action* of this group of muscles becomes very evident when their points of origin and insertion are considered. The first three muscles agree in having a similarity of origin—viz. the hyoid bone—which, when they exert their action, is made a fixed point by the contraction of the steno-hyoid, omo-hyoid, and thyro-hyoid muscles. When they are excited to action and contract co-ordinately, they exert a traction force upon the lower jaw, which becomes depressed and the mouth is opened. The platysma myoides, acting from its origin at the upper part of the chest, has a similar but less marked action than the preceding. The posterior portion of the digastric takes no part in the ordinary movements of mastication. When, however, the mouth is to be widely opened, or when the lower jaw is prevented from being depressed, then it is that the superior maxilla is somewhat elevated and the entire head thrown backward: under these circumstances the posterior portion of the digastric, acting from the hyoid bone as a fixed point, exerts a traction force upon the posterior portion of the head and depresses it. Usually, however, this portion of the muscle is not active, as the superior maxilla takes no part in the movements of mastication, merely offering a surface against which the lower jaw can press and grind the food.

Elevator Muscles of the Lower Jaw.—The *temporal* muscle is broad and radiating, and occupies the entire extent of the temporal bone. It arises from the whole length of the temporal ridge and fossa: its fibres then descend and converge to form a flat, strong tendon which is inserted into the coronoid process of the inferior maxilla.

The *masseter* muscle is short, thick, quadrilateral in shape, and consists of two planes of muscular fibres, an external and internal. The external layer arises from the malar process of the superior maxilla and the anterior two-thirds of the zygoma by a strong aponeurosis: its fibres pass obliquely downward and backward to be inserted into the angle and inferior half of the ramus of the lower jaw. The internal layer arises from the posterior third of the zygoma; its fibres then pass downward and forward to be inserted into the upper half of the ramus.

The *internal pterygoid* muscle is thick and quadrangular in shape. It arises from the pterygoid fossa, and descends downward, backward, and outward to be inserted into the inner surface of the ramus and angle of the lower jaw. It is sometimes termed the internal masseter, from its appearance and the direction of its fibres.

The *action* of this group of muscles becomes apparent when their anatomical relationship is considered. When the mouth has been opened the simultaneous contraction of these muscles elevates the jaw and closes the mouth with considerable force. The power with which the muscles of this group contract is well shown by the carnivorous animals, in which, from the nature of the food (and the construction of the temporo-max-

illary articulation), the lower jaw must be elevated with great force in order to divide and crush it. Even in man their power is very great, and depends, as in the carnivorous animals, upon the shortness and thickness of the muscular fibres. By their contraction the food introduced into the mouth is divided and crushed.

Muscles which Produce the Antero-posterior, the Lateral, and Grinding Movements of the Jaw.—The *external pterygoid* muscle is short, somewhat conical in shape, and arises by two heads—one from the under surface of the great wing of the sphenoid bone, the other from the tuberosity of the superior maxillary and palate bone. Its fibres pass almost horizontally backward to be inserted into the neck of the condyle of the lower jaw and the interarticular fibro-cartilage. When the muscle of either side contracts from its point of origin, it draws the condyle of the corresponding side forward in the glenoid fossa, and deviates the symphysis of the jaw to the opposite side. When the two muscles contract simultaneously, they antagonize each other in the median line, and as a result draw the jaw forward to such an extent that the lower teeth project beyond the upper teeth. The external pterygoids are assisted in these movements by the external portion of the masseter and the anterior fibres of the temporal muscle. The posterior movement of the jaw by which it is returned to its natural position is accomplished by the contraction of the posterior fibres of the temporal, internal portion of the masseter, digastric, genio-hyoid, and mylo-hyoid muscles. The antero-posterior or sliding movement is well exhibited by the rodent animals.

The *lateral* movements of the jaw are produced by the alternate contraction of the external and internal pterygoid muscles on either side. These movements are concerned in the act of crushing or grinding the food, and are well exhibited by the herbivorous animals, whose food is of such a nature as to require considerable grinding before it is ready for digestion. The *grinding* movements of the jaw are produced by the action of the temporal, masseter, and pterygoid muscles.

For the proper mastication of the food it is essential that it should be kept between the opposing surfaces of the teeth. This is accomplished by the tonic contraction of the orbicularis oris and buccinator muscles acting from without, and the tongue acting from within. The importance of the orbicularis oris and buccinator muscles in retaining fluids and solids within the mouth is readily shown when they undergo paralysis either from disease or from division of the facial nerve endowing them with motility. Under these circumstances, there being nothing to antagonize the action of the tongue, the food is pushed outward and accumulates between the teeth, giving rise to great inconvenience. The angle of the mouth becoming depressed, the fluids flow out over the chin.

The tongue is largely employed in opposing the buccinator muscle and keeping the food between the teeth, in shifting it from one side of the mouth to the other, and in turning it over constantly so that it may be thoroughly masticated. It is capable of performing these varied movements and of altering its general shape by the action of its extrinsic and intrinsic muscles. The importance of the tongue as an

agent in mastication, and the injurious results that follow its paralysis, are shown by division of the hypoglossal nerves. When this has been done, immediately the tongue ceases its movements and becomes perfectly flaccid: the animal is unable to lap up food with its tongue, or with the food introduced within the mouth is unable to turn it over or move it from side to side.

NERVOUS MECHANISM OF MASTICATION.—The movements of mastication, though originating in efforts of the will and under its control, are for the most part of an automatic or reflex character; for when once established by a voluntary effort these movements continue for an indefinite period—so long, in fact, as the impressions which the food makes upon the afferent nerves are received by the nerve-centres regulating and controlling these movements. That the masticatory movements are of this reflex nature is shown by the fact that they will be maintained even though the voluntary effort which called them forth has subsided and the attention has been directed to some entirely different subject. It would appear that all that is necessary is the exciting action of the food upon the periphery of the sensitive nerves distributed to the tongue and mouth.

Nervous Circle of Mastication.

Afferent or Excitor Nerves.	*Efferent or Motor Nerves.*
1. Lingual branch of fifth pair;	1. Inferior maxillary division of fifth pair;
2. Glosso-pharyngeal.	2. Hypoglossal or sublingual;
	3. Facial or portio dura.

The nerve-centre co-ordinating the movements of mastication is situated in the medulla oblongata. The afferent or excitor nerves which receive the impressions of the food are distributed largely to the mucous membrane of the tongue. When these impressions are received by the centre in the medulla oblongata it generates nervous impulses, which, passing outward through motor nerves, excite contraction in the masticatory muscles. The motor nerves innervating the muscles are—1. The small root of the fifth nerve, which, after emerging from the cavity of the cranium through the foramen ovale, joins the inferior maxillary division of the large or sensory root. It then is distributed to the masseter, temporal, internal and external pterygoids, anterior belly of the digastric, and mylo-hyoid muscles, and endows them with motility. 2. The hypoglossal nerve, which, after emerging through the anterior condyloid foramen, passes downward and forward to be distributed to the extrinsic and intrinsic muscles of the tongue. 3. The facial or portio dura, which, after emerging from the stylo-mastoid foramen, is distributed to the muscles of the face. Irritation of any one of these nerves produces convulsive movements in the muscles to which it is distributed, while their division is followed by paralysis of these muscles. The medulla not only generates the motor impulses, but is also capable of co-ordinating them in such a manner that the movements of mastication may be directed toward the accomplishment of a definite purpose.

Insalivation.

Insalivation is that portion of the digestive process which consists in the incorporation of the saliva with the food, and takes place for the most part during the act of mastication. The influence which the saliva exerts upon the food is twofold—viz. physical and chemical—and is important in the digestive process; for the saliva not only softens and moistens the food, thus facilitating mastication and deglutition and the subsequent action of the digestive fluids, but it also exerts a chemical action upon the starchy elements of the food and transforms them into glucose or grape-sugar. Imperfect insalivation is the usual accompaniment of imperfect mastication, and results in a partial digestion only of the amylaceous compounds, subsequent disorders of nutrition, and a lessening of the bodily energy.

The saliva that is incorporated with the food, and which is ordinarily present in the mouth, is a complex fluid, composed of the various secretions of the parotid, submaxillary, and sublingual glands and the muciparous follicles of the mouth, which collectively constitute the salivary apparatus. A knowledge of the physiological anatomy of the glands necessarily precedes the consideration of the mechanism of their secretions and their physiological properties and functions.

The *parotid gland* is the largest of the three salivary glands, and weighs from three to five drachms. It is situated on the side of the face, in front of and partly below the external ear: it extends deeply inward toward the base of the skull, and is connected with the underlying structures. Externally, it is covered by the skin and fascia; from its anterior border is given off the common excretory duct. The parotid is a conglomerate or racemose gland consisting of an immense number of small lobules united together by a dense areolar tissue, in the meshes of which are distributed blood-vessels and nerves. The areolar tissue surrounding the lobules is continuous with that upon the surface, the gland possessing no proper coat. The gland receives its blood-supply from the branches of the external carotid artery. The nerves distributed to its substance are derived ultimately from the facial, the trigeminal, and the carotid plexus of the sympathetic.

The excretory duct of the parotid gland (Steno's duct) measures about two and a half inches in length and one-eighth of an inch in diameter. It makes its appearance at the anterior portion of the gland, then passes forward across the masseter muscle to its anterior border, where it turns inward and pierces the buccinator muscle. It then passes for a short distance obliquely beneath the mucous membrane, and opens by a small orifice on the inner surface of the cheek opposite the second molar tooth. It consists of two coats—an external, composed of fibrous tissue in which are scattered contractile fibres, and an internal, composed of mucous membrane continuous with that of the mouth, covered by columnar epithelium.

The submaxillary gland is situated below the jaw in the anterior part of the submaxillary triangle. It is intermediate in size between the parotid and sublingual glands, and weighs about two and a half drachms. It rests against the mylo-hyoid muscle, and is covered by the skin and platysma myoides muscle. It receives its blood-supply

from the facial and lingual arteries. The nerves are derived directly from the submaxillary ganglion, remotely from the sympathetic, the chorda tympani, and the trigeminal or fifth nerves. The duct of the submaxillary gland (Wharton's duct) passes upward between the muscles to the side of the frænum of the tongue, and opens by a minute orifice upon the surface of a small papilla. It has the same structure as the parotid duct, but its wall is much thinner, and it is about two inches long. In its structure it resembles the parotid gland, but its lobules are larger and not so firmly united together by the areolar tissue.

The *sublingual* gland is the smallest of the three, and weighs about a drachm. It is situated on the anterior part of the inner surface of the inferior maxilla, just beneath the mucous membrane of the floor of the mouth, and forms a projection between the tongue and gums of the lower jaw. In structure it resembles the parotid and sublingual glands. Its blood-supply is derived from the sublingual and submental arteries, its nerves from the lingual branch of the fifth nerve. The excretory ducts (the ducts of Rivini) are from eight to twenty in number, and open into the mouth on either side of the frænum on the projecting crest of the mucous membrane. One or two ducts unite to form a common duct (the duct of Bartholini), which joins the Whartonian duct.

In their minute structure the salivary glands strongly resemble each other. They are conglomerate, being composed of irregularly-shaped lobules which are united together by dense areolar tissue, and connected with branches of the salivary ducts. Each lobule is made up of small vesicles or follicles, which are the terminal expansions of small branches of the ducts. The vesicles measure about the $\frac{1}{500}$th of an inch in diameter. The wall of the vesicle, formed by a delicate basement membrane, is covered externally by a fine plexus of capillary blood-vessels, and in the case of the parotid gland is lined internally by a layer of epithelium cells, which are granular and contain a distinct nucleus. In the submaxillary gland the vesicles contain large, clear, non-granular, but nucleated cells, the so-called *mucous cells,* which are simply the lining cells which have undergone a mucous transformation. In the sublingual gland the vesicles also contain the mucous cells, but they are never present in the parotid. The excretory ducts are lined with epithelial cells, which probably play some part in the secretion of the salivary fluids.

The terminations of the nerves in the submaxillary glands have been thoroughly studied by Pflüger in the rabbit. According to him, medullated nerve-fibres pass to the vesicles of the gland, then penetrate the basement membrane, and pass between the cells lining the vesicle. The axis-cylinder advances still farther, penetrates the substance of the cell, and ends in its nucleus. The termination of the nerves in the parotid gland is the same as in the submaxillary.

Parotid Saliva.—The saliva from the parotid gland can be obtained by the introduction of a catheter having a diameter of the one-twenty-fifth of an inch into the orifice of the duct of Steno. The fluid will then flow readily from the other extremity as it projects between the lips. In this way the pure secretion may be obtained free from any admixture with the secretions of the other glands or buccal epithelium. By this method Prof. Dalton collected 31.1 grammes (479.8 grains)

from the human subject in twenty minutes, and in seven different observations, comprising altogether three hours and nine minutes, he was able to collect a little over 194 grammes (2993 grains). The parotid saliva has also been obtained from fistulous openings in the duct. From the dog the saliva can be readily obtained by exposing the duct of Steno and introducing a catheter into it. In this animal the fluid is limpid and watery and without any viscidity. From all these observations it may be stated that the parotid saliva is clear and watery in appearance, possessing neither opalescence nor turbidity. It is distinctly alkaline in reaction, and becomes turbid when subjected to the action of heat or when nitric acid is added or sodium sulphate in excess. It has a specific gravity of 1003 or 1004.

Chemical Composition of Parotid Saliva (Prof. Dalton).

Water	983.308
Organic matter precipitated by alcohol	7.352
Substance destructible by heat, but not precipitated by acids or alcohol	4.810
Sodium sulphocyanide	0.330
Calcium phosphate	0.240
Potassium chloride	0.900
Sodium chloride, Sodium carbonate	3.060
	1000.000

As will be seen from this analysis, the parotid saliva consists mainly of water, with a small proportion of organic matter, which is coagulable by heat, mineral acids, and alcohol and inorganic substances. A trace of a sulphocyanogen compound can be obtained by the addition of a salt of iron, as shown by a distinct red color.

Although the secretion of the parotid saliva is constant, yet during the process of mastication it is poured out in greatly increased quantity, and, as was observed by Colin, the increase in the amount of secretion was most marked upon the side that was engaged in mastication. The same observation was made in the human subject by Dalton, who found that when a canula was introduced into the duct on the same side that mastication was being performed, he was enabled to obtain in twenty minutes 374 grains (24.25 grammes), while from the other side only 127 grains (8.26 grammes) could be obtained. It would thus seem that the movements of mastication influence to some extent the secretion from the parotid glands. The introduction of sapid substances into the mouth, or even the sight of food, will increase the flow from the glands. Dry food also acts as a stimulus, and increases the amount of secretion to a much greater extent than food that contains moisture.

From the manner in which mastication and the character of the food influence the flow of parotid saliva it would be inferred that they are important adjuncts to that process; and this is really the case. The situation of the orifice of the parotid duct is such that when the fluid is poured into the mouth it directly mixes with the food and is incorporated with it during mastication, and thus fulfils the mechanical function of softening and moistening the food and facilitating deglutition. It also exerts a chemical action upon certain elements of the food, which will be considered when treating of the mixed saliva.

Submaxillary Saliva.—The submaxillary saliva can be obtained in the same way as the parotid by introducing a canula into the duct of Wharton. When the gland is excited to activity the fluid flows from the canula in large drops, which are perfectly clear, but viscid and alkaline in reaction.

Chemical Composition of Submaxillary Saliva (Bidder and Schmidt).

Water		991.45
Organic matter		2.89
Inorganic matter	Calcium chloride, Sodium chloride	4.50
	Calcium carbonate, Calcium phosphate, Magnesium phosphate	1.16
		1000.00

The flow of the submaxillary saliva, like that of the parotid saliva, is more or less constant, but is nevertheless increased in amount by the movements of mastication and the presence of sapid substances in the mouth. The function of the submaxillary saliva is mainly physical. Owing to its viscidity, it serves to unite together the particles of the food, coats over the surface of the bolus, and thus facilitates the passage of the bolus through the pharynx and œsophagus into the stomach.

Sublingual Saliva.—The sublingual saliva can be obtained by introducing a canula into the duct, as in the preceding instances. As it flows from the canula it is exceedingly viscid and glutinous and of a distinctly alkaline reaction. It is composed of water, organic matter, and inorganic principles. It is secreted during the acts of mastication and deglutition.

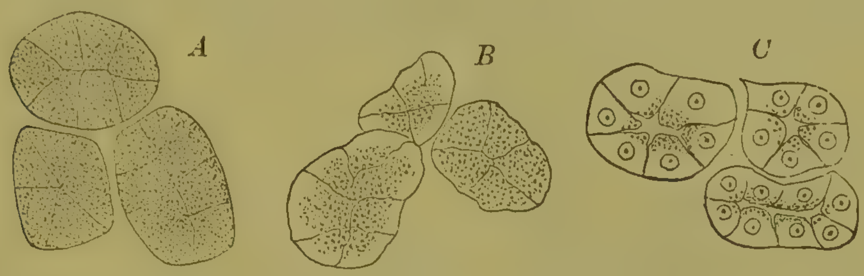
The small racemose glands imbedded in the mucous membrane on the inner surface of the cheeks and lips, on the hard and soft palates, upon the surface of the tongue and pharynx, secrete a mucus which is viscid in character, grayish in color, and contains when free from admixture with other secretions epithelial cells and leucocytes.

During and after secretion very remarkable structural changes take place in the cells lining the acini of the glands, which are in some way connected with the elaboration of the essential constituents of these fluids. In the case of the parotid gland, which may be regarded as a serous gland, the following changes have been observed by Langley: During the period of rest the epithelial cells are large and swollen and encroach upon the lumen of the acinus: their substance is so completely filled with fine granules as to almost entirely obscure the nucleus. When secretion becomes active, however, the granular matter begins to disappear from the outer region of the cells and move toward the inner border. At the close of active secretion the granules almost entirely disappear, and the cells become small and shrunken. It would then appear that during rest the gland-cells manufacture granules, which are discharged from the cells into the lumen during secretion to take some part in the composition of the parotid saliva. (See Fig. 32.)

In the submaxillary gland the changes that take place in the mucous cells are somewhat more complex. During rest their cells are large,

clear, and highly refractive, loaded with mucigen, and do not stain with carmine. They contain a nucleus surrounded by a small amount

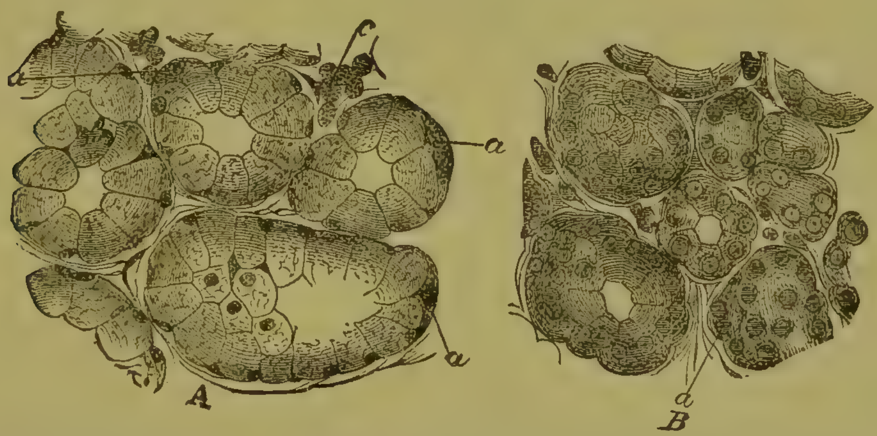
FIG. 32.



Changes in the Parotid during Secretion (Langley): The figure, which is somewhat diagrammatic, represents the microscopic changes which may be observed in the living gland. *A*, during rest. The obscure outlines of the cells are introduced to show the relative size of the cells; they could not be readily seen in the specimen itself. *B*, after moderate stimulation; *C*, after prolonged stimulation. The nuclei are diagrammatic, and introduced to show their appearance and position.

of protoplasm, which is placed near the limiting membrane of the acinus. During secretory activity the mucous cells disintegrate and yield up their mucigen. At the end of prolonged activity they have entirely disappeared, and their place taken by small, dark pro-

FIG. 33.



Section of a "Mucous" Gland: *A*, in a state of rest; *B*, after it has been for some time actively secreting (after Lavdowsky); *a*, demilune cells; *c*, leucocytes lying in the interalveolar spaces. The darker shading in both figures is intended to indicate the amount of staining.

toplasms, which stain readily with carmine. The gland-cells thus appear to be engaged in the elaboration of mucigen during the rest of the gland, which is discharged during the secretory activity (Fig. 33).

Mixed Saliva.—The saliva that can be readily obtained from the mouth is a complex fluid, composed of the various secretions of all the salivary glands. When first expelled it is frothy, colorless, slightly turbid, and somewhat viscid. As it contains but few solids, its specific gravity is low, ranging from 1.002 to 1.008. If the saliva be abundant and in a normal condition, the reaction is distinctly alkaline; but if it be scanty or obtained from individuals suffering from disorders of the alimentary canal, the reaction may become neutral or even distinctly acid. According to Prof. Flint, this occurs also after prolonged and exhausting muscular exertion.

When examined microscopically it is seen to contain epithelium cells, leucocytes, salivary corpuscles, particles of food, and occasionally crypto-

gamic spores, the Leptothrix buccalis. When subjected to the influence of heat or the action of acids, the saliva becomes turbid, and when treated with alcohol in excess an abundant white precipitate takes place.

The chemical analysis of the mixed saliva made by Bidder and Schmidt is probably the most accurate, and is presented in the following table:

Composition of Human Saliva.

Water	995.16
Epithelium	1.62
Soluble organic matter	1.34
Potassium sulphocyanide	0.06
Sodium, calcium, and magnesium phosphates	0.98
Sodium and potassium chloride	0.84
	1000.00

Water constitutes the main constituent, amounting to about 95 per cent. of the saliva. It is the result of a transudation from the blood-vessels during the functional activity of the salivary glands, and holds the other constituents of the saliva in solution, and at the same time assists in the solution of the different articles of food.

The organic matter consists mainly of mucin, globulin, serum, albumen, and ptyalin, and can be readily obtained by precipitation. It is coagulated by absolute alcohol in excess, but is unaffected by heat or acids. A ready means of obtaining the organic matter is to filter the saliva and free it from mucus: then by adding an excess of absolute alcohol, ten to fifteen times its bulk, an abundant precipitate of a grayish color takes place, composed chiefly of proteid materials. After a week or ten days the precipitate may be collected by filtration, dried, and kept for any length of time. After coagulation it is insoluble in water, but soluble to a very slight extent in glycerin.

The sulphocyanide of potassium is a normal ingredient of the saliva, though it is by no means invariably present. It is mainly derived from the parotid saliva, and its presence can be shown by the addition of a drop of a very dilute solution of the perchloride of iron to clear saliva, when a characteristic red color is developed. Undiluted perchloride of iron produces a deep-red color. The presence of some sulphocyanide, either of sodium or potassium, was satisfactorily determined by Longet, who, after collecting about three quarts of saliva from forty soldiers in half an hour, concentrated it so that all the sulphocyanide was contained in a few drops. Upon the addition then of the perchloride of iron an intense red color, the characteristic reaction, was at once produced. It probably prevents the development of fungi and the decomposition of particles of food which may have lodged between the teeth.

Quantity of Saliva.—The estimation of the total quantity of mixed saliva secreted in twenty-four hours is exceedingly difficult, and the results obtained must be only approximative. It is of course subject to considerable variation depending upon habit, the nature of the food, etc. The experiments of Prof. Dalton and the results obtained by him are eminently trustworthy, and in all probability represent as nearly as possible the exact amount secreted. He found that without any artificial stimulus he was enabled to collect from the mouth about 36 grammes

(540 grains) of saliva per hour, but upon the introduction of any unirritating substance into the mouth the quantity could be greatly increased. During mastication also the saliva was poured out in greater abundance, the amount depending upon the relative dryness of the food. By adding together the amount secreted during complete mastication and the amount secreted during twenty-two hours a tolerably accurate calculation could be made. The former was determined by estimating the amount of saliva that wheaten bread and fresh cooked meat would absorb during mastication. He found that the former absorbed 55 per cent. of its weight, and the latter 48 per cent. If, therefore, the average quantity of bread and meat required daily by a man of ordinary physical development and activity be assumed to be 540 grammes (19 oz.) of the former and 450 grammes (16 oz.) of the latter, these two substances would absorb respectively 297 grammes (4573.8 grains) and 216 grammes (3326.4 grains), making a total of 513 grammes (7900 grains). If, therefore, the amount secreted during the two hours of mastication be added to the amount secreted during the remaining twenty-two hours, supposing that it continues at the rate of 36 grammes per hour, we have a total amount of $513 + 792$ grammes, or 1305 grammes (19,197 grains), or about $2\frac{1}{2}$ pounds.

Function of Saliva.—The constant presence of the salivary glands in the different orders of animals, and the large amount of secretion which they daily pour into the alimentary canal, lead to the conclusion that this fluid plays an important function in the general process of digestion. The mechanical influence of the saliva in softening and moistening the food during mastication, thus facilitating deglutition, has been alluded to in connection with the properties of the different secretions.

Independent of this mechanical influence, the saliva exerts a chemical influence upon the starchy elements of the food, transforming them into glucose or grape-sugar. This was discovered by Leuchs in 1831. This action of the saliva will be more readily manifested if the starch has been boiled than if it be in the raw state, though even in the latter condition it will be transformed, but much less rapidly. It has also been shown that not only will the mixed saliva exert this action, but it is almost equally well shown if the secretions from either the parotid, submaxillary, or sublingual glands be added to the starch. This action of the saliva, and the rapidity with which the conversion takes place, can be readily demonstrated by retaining in the mouth some previously boiled starch, even for a few minutes, when the presence of the sugar may be recognized by the sense of taste. The same change may be demonstrated in the following way: Place in a test-tube a small quantity of saliva that has been filtered; add about three to five times its quantity of thin hydrated starch. Place the test-tube for a few minutes in a water-bath at a temperature of about 100° F. It will then be found that if iodine be added the characteristic blue color will no longer present itself, the starch having entirely disappeared. But if then to the mixture a few drops of Fehling's solution of copper be added, a copious yellow or orange deposit of the oxide of copper takes place, showing the presence of grape-sugar. Mialhe demonstrated that during this transformation the starch was first converted into dextrin, and

then into sugar. The presence of the dextrin can be shown by the addition of iodine to the mixture, when a violet color will be produced. It is at present undetermined whether all the starch is converted directly into dextrin, and then into sugar, or whether the saliva divides the starch into sugar and dextrin, and then transforms the dextrin. In either case the change, according to Prof. M. Foster, consists in the assumption of a molecule of water; the nature of the chemical change is shown by the following formula:

$$C_{18}H_{30}O_{15} + 3H_2O = \underset{\text{Grape-sugar.}}{C_6H_{12}O_6} + \underset{\text{Dextrin.}}{2(C_6H_{10}O_5)} + 2H_2O = 3(C_6H_{12}O_6).$$

The amylolytic action of the saliva depends upon the presence of an organic ferment which has been termed by Berzelius *ptyalin*. This substance can be obtained either from the salivary glands or the saliva itself. In the first instance, the salivary glands of a rabbit or sheep are removed and freed from the connective tissue surrounding them. They are then minced up finely, placed in a flask, and covered with absolute alcohol. At the end of twenty-four hours the liquid is poured off and the alcohol remaining in the gland strained through muslin. The residue is then placed in a glass beaker and covered with glycerin and allowed to remain for several days. Again strain the whole material through cloth, and then filter. From the filtrate thus obtained the ptyalin can be precipitated by alcohol. It is then collected and dried over sulphuric acid. In the second instance, the saliva after being collected is treated with phosphoric acid until it becomes distinctly acidified, and is then neutralized by adding milk of lime. A copious precipitate is produced, which carries down with it the ptyalin. After removing the precipitate by filtration it is again dissolved in water and again filtered. If then to the filtrate an excess of alcohol be added, there takes place in a short time a flocculent precipitate of ptyalin, which can be collected and dried over sulphuric acid.

Ptyalin belongs to the ferment group of substances, and effects the transformation of starch into sugar simply by its presence, undergoing itself no perceptible consumption in this process. It is an amorphous albuminous substance, but differs from other forms of albumen in all its reactions. That this substance is the active principle of the saliva can be demonstrated by dissolving it in water, when it becomes as active as the original saliva. Although it exists in exceedingly small quantity, the energy of its action is very great: according to Mialhe, one part of ptyalin is capable of transforming two thousand parts of starch.

The activity of the ptyalin is modified by various external conditions, among which may be mentioned the chemical reaction of the medium in which it is placed. It is most active when the medium is moderately alkaline, but its activity is arrested either by strong alkalies or acids, though the presence of a small percentage of an acid does not appear to have any effect in either hastening or retarding the process. This fact has a bearing upon the question as to whether the action of the saliva is interfered with in the stomach by the presence of the gastric juice. At present it is a disputed matter, but the weight of authority is in favor of the view that the transforming action may continue even during gas-

tric digestion. The temperature also influences the rapidity with which the transformation of the starch is effected. At a temperature of from 95° to 106° F. the ptyalin acts most energetically, while its activity is entirely arrested by reducing the temperature to the freezing-point or raising it to the boiling-point.

Nervous Mechanism of the Secretion of Saliva.—The secretion of saliva is a reflex act and largely under the control of the medulla oblongata. During the intervals of mastication the salivary glands are at rest and the amount of saliva excreted but small. When food is introduced into the mouth, however, and the movements of mastication begin, at once a copious secretion and discharge of saliva takes place, the amount varying with the nature of the food. In this case the impressions made by the food upon the peripheral terminations of the nerves in the mucous membrane of the mouth are transmitted upward along afferent nerves to the medulla oblongata, and there excite activity in the nerve-centres, these centres, in turn, generating impulses which are transmitted outward along efferent nerves to the gland structures, with the effect of stimulating them and increasing the flow of saliva. The nerve-centres and nerves constituting the reflex circle concerned in the secretion of the saliva are shown in the following table—viz.:

Nervous Circle of Insalivation.

Afferent or Excitor Nerves.	*Efferent or Motor Nerves.*	*Centres.*
Lingual branch of fifth pair. Glosso-pharyngeal.	Chorda tympani for the submaxillary and sublingual glands. Auriculo-temporal branch of fifth nerve for parotid glands.	Medulla oblongata. Submaxillary ganglion, the latter acting antagonistically to the former.

That the secretion of the saliva is regulated by the above mechanism, and that the lingual branch of the fifth pair of nerves and the glosso-pharyngeal are the afferent nerves, can be readily demonstrated by exposing the glands and their nervous connections and subjecting them to experiment. Under such circumstances, if a canula be placed in the duct of the submaxillary gland, and the lingual nerve be then stimulated by an interrupted current of moderate strength, a copious flow of saliva at once takes place. If now the glosso-pharyngeal nerve be stimulated in a similar manner, the effect on the secretion will be the same. Division of these two nerves in an animal, thus preventing the impressions of the food from reaching the medulla oblongata, is followed by a marked diminution in the amount of saliva secreted. It is evident, therefore, that the lingual branch of the fifth pair and the glosso-pharyngeal are the chief afferent nerves which conduct impressions from the mouth to the salivary centres in the medulla. These centres, however, may receive impulses and be excited to activity by impulses coming through other nerves—*e. g.* the pneumogastric when the mucous membrane of the stomach is stimulated; the sciatic when after division its central end is stimulated; through nerve-fibres that originate higher up in the brain and are stimulated by ideas and emotions.

Whenever these centres are stimulated, either by stimuli coming

through afferent nerves from the periphery or by emotions and ideas originating in the brain, impulses are generated which pass outward through the chorda tympani nerve to the submaxillary and sublingual glands, and through the auriculo-temporal nerve to the parotid gland. The secretory activity of the salivary glands is influenced also by nervous impulses reaching them through the branches of the sympathetic nerve, the branches for the submaxillary and sublingual glands being derived from the plexus surrounding the facial artery, those for the parotid gland being derived from the plexus surrounding the internal maxillary artery. That the chorda tympani and auriculo-temporal are the channels for the transmission of the efferent impulses can be demonstrated by exposing the nerves in their course and dividing them. When the chorda tympani nerve is divided in the upper part of its course, there is a complete cessation in the flow of saliva from the submaxillary gland; and when the auriculo-temporal nerve is divided, there is a diminution in the secretion of the parotid gland.

The manner in which the chorda tympani increases the secretion and flow of saliva from the submaxillary gland can be demonstrated by the following experiment: If a canula is introduced into Wharton's duct and the rate of the flow estimated, and the nerve is then divided, the secretion is at once arrested. If then the peripheral end of the nerve be stimulated by the interrupted current, a copious secretion of a thin saliva is produced, which is accompanied by a marked dilatation of the blood-vessels of the gland, the quantity of blood passing through them being enormously increased, so that the venous blood acquires a bright arterial hue and a distinct pulsation is observed in the small veins. It would appear that the chorda contains fibres which inhibit the action of a local vaso-motor mechanism, thus permitting the blood-vessels to dilate. It might be inferred that the increase in the flow of saliva is due to filtration, the result of the increased blood-supply to the gland, and not to the influence of any true secretory fibres stimulating the activities of the secretory cells. That this is not the case, however, can be demonstrated in several ways: First, the pressure in the duct of the submaxillary gland, as shown by the mercurial manometer, rises considerably, when the gland is secreting, above the pressure in the carotid artery, which could not be the case if it were due to a mere filtration; for if pressure alone were the cause, the flow of saliva would cease as soon as the pressure in the tube equalled the pressure in the blood-vessels. Second, even in the absence of blood the gland can be made to yield a secretion, as shown by stimulating the nerve in a recently-killed animal. Third, after the injection of atropia into the circulation the secretion is abolished, but the local vaso-motor mechanism is unimpaired, for stimulation of the nerve, as in the previous instance, gives rise to a dilatation of the vessels and an increased blood-supply. It would therefore appear that the chorda tympani contains two sets of fibres—one regulating the blood-supply to the gland, the other exciting the true secretory cells.

The sympathetic nerve apparently exerts an influence antagonistic to the chorda tympani, for if the nerve be exposed and stimulated with the interrupted current, there follows at once a marked contraction of

the arterioles of the gland and a diminution in the blood-supply. Nevertheless, the gland pours out a saliva, which is different, however, from that secreted when the chorda tympani is stimulated. The quantity is less; it is more viscid and is richer in organic matter, is of a higher specific gravity, and more active in the transformation of starch into glucose. On account of the activity of the local vaso-motor mechanism in the gland, division of the sympathetic is not, as might be expected, followed by a dilatation of the blood-vessels.

The influence of the auriculo-temporal branch of the fifth nerve upon the parotid gland is similar to the action of the chorda tympani. The active fibres of this nerve are probably derived from the facial nerve. If the nerve be stimulated by the interrupted current, there follows a dilatation of the blood-vessels and an abundant discharge of a thin saliva, rich in water and salts, but containing a small amount of organic matter. When the sympathetic fibres passing to the gland are stimulated, the blood-vessels contract and the secretion is abolished, but at the same time there is an increased activity of the secreting cells, for subsequent stimulation of the auriculo-temporal nerve not only causes an increase in the amount of watery and saline constituents, but the organic matter is enormously increased above that discharged when the auriculo-temporal is stimulated first. The sympathetic appears to exert some trophic influence upon the gland.

Deglutition.

Deglutition is that part of the digestive process which is concerned in the transference of the food from the mouth through the pharynx and œsophagus into the stomach. It is an exceedingly complex act, occurring in a rapid and almost convulsive manner, and involves the action of a large number of structures, all of which are made to act in proper sequence under the co-ordinating influence of the nervous system. The movements of the first part of this process are voluntary—of the latter part, involuntary and entirely reflex, being controlled by the centre for deglutition situated in the medulla oblongata. Deglutition may be divided, for convenience of description, into three stages—viz.:

1. The passage of the food from the mouth into the pharynx;
2. The passage of the food from the pharynx into the œsophagus;
3. The passage of the food from the œsophagus into the stomach.

In the first stage of the process the food, which has been formed into a bolus by mastication and insalivation, is placed upon the superior surface of the tongue; the mouth is then closed, respiration momentarily suspended, while the tip of the tongue is applied against the posterior surfaces of the teeth. The tongue then arches upward from before backward against the roof of the mouth and pushes the bolus backward through the isthmus of the fauces into the pharynx. This completes the first stage. It is a voluntary effort, and accomplished mainly by the action of the tongue. That the tongue is the essential agent in this process is readily shown by the difficulties those persons experience in swallowing in whom it has been removed or paralyzed or is congenitally

absent. Under such circumstances the greatest difficulty is experienced, and deglutition is found to be almost impossible until the bolus has been artificially placed within reach of the muscles of the palate and pharynx. Division of the hypoglossal nerves in animals, with the effect of paralyzing all of the intrinsic and extrinsic muscles of the tongue, is followed by an equally marked impairment of the power of swallowing.

In the second stage of deglutition the food is passed through the pharynx by movements which are much more complicated and wholly involuntary. The action of the mechanism by which the food is passed from the base of the tongue through the pharynx will be better understood by considering briefly its physiological anatomy.

The pharynx is a funnel-shaped cavity extending from the base of the skull to the lower border of the cricoid cartilage. Superiorly it is attached to the basilar process of the occipital bone, posteriorly to the prevertebral fasciæ and muscles, laterally to the areolar tissue around the styloid process, anteriorly to the posterior nares, mouth, and larynx. The anterior wall is imperfect, and presents openings which communicate with the nose, mouth, and larynx. In the lateral wall on either side is the orifice of the Eustachian tube, which leads into the middle ear. Partially separating the mouth from the pharynx is a musculo-membranous structure, the soft palate, or velum pendulum palati. It is attached above to the hard palate: its inferior or free border is directed downward and backward, and presents in the centre a conical process, the uvula, formed by the azygos uvulæ muscles. On either side the soft palate presents two curved processes, the anterior and posterior half-arches. The anterior arches are formed by the palato-glossus muscles, and are covered over by mucous membrane. They have their origin in the side of the palate near the base of the uvula: after curving downward and forward they are inserted into the side of the tongue. The posterior arches are formed by the palato-pharyngei muscles. They also arise in the palate, and, after curving downward and backward, are attached to the posterior border of the thyroid cartilage. Between the arches are situated the tonsils: they are oval in shape, follicular in structure, and about the size of a hazelnut. (See Fig. 34.)

The levator palati muscles, by which the soft palate is elevated and the opening of the Eustachian tubes partially closed, arise from the apices of the petrous portions of the temporal bones and the cartilaginous portion of the Eustachian tubes: the fibres then pursue a downward and inward direction and are inserted into the soft palate.

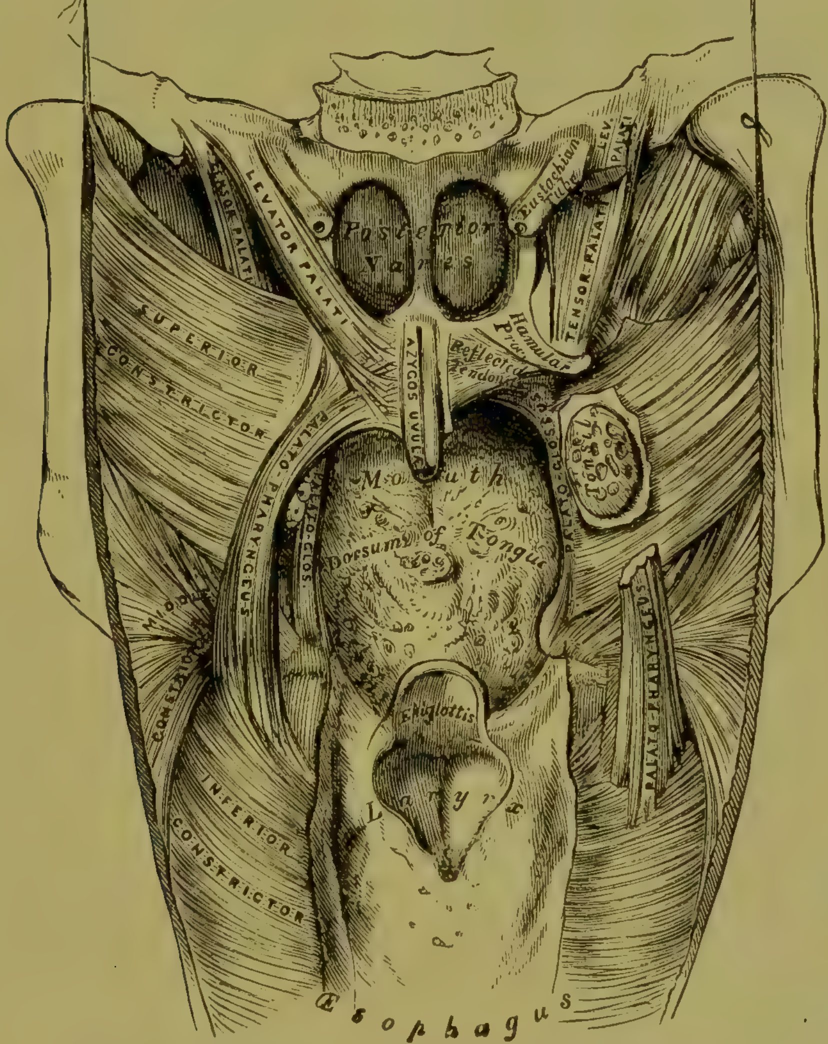
The tensor palati muscles, as the name implies, make the palate tense, and during deglutition assist in opening the Eustachian tubes so as to admit air into the tympanic cavity. The fibres arise from the scaphoid fossæ and Eustachian tubes; they then pass vertically downward, wind around the hamular process, where the muscle becomes tendinous, and then expand into a membranous aponeurosis which interlaces with fibres of the opposite side.

The isthmus of the fauces is the opening by which the mouth and pharynx communicate. It is bounded laterally by the anterior and posterior arches, above by the soft palate, and below by the base of the tongue.

The walls of the pharynx are formed by three pairs of constrictor muscles, the superior, middle, and inferior, and the stylo-pharyngei. These muscles are so arranged that when they contract from above downward the food is necessarily forced into the œsophagus.

The superior constrictors are flat, quadrilateral muscles, and form the upper part of the pharynx. Their fixed point of origin is the lower portion of the internal pterygoid plate, the aponeurosis of the soft

Fig. 34.



Muscles of the Soft Palate: pharynx being laid open from behind.

palate, and the pterygo-maxillary ligament: their fibres then pursue a horizontal direction backward, and are inserted into the median raphé.

The middle constrictors are flat, fan-shaped muscles, lying in a plane posterior to the superior constrictors. Their fibres rise from the greater and lesser cornua of the hyoid bone, and then, passing backward, radiate and interlace with fibres of the opposite side of the median line.

The inferior constrictors lie posterior to the middle. They are the largest and strongest of the three muscles: their fibres, arising from the posterior borders of the thyroid and the side of the cricoid cartilages,

pass backward, the inferior horizontally, the superior upward, and are inserted into the pharyngeal aponeurosis in the median line.

The stylo-pharyngei muscles are long and slender. They arise from the base of the styloid processes, and then pass downward between the superior and middle constrictors to be inserted into the posterior border of the thyroid cartilage. Some of their fibres interlace with the constrictors and stylo-pharyngei muscles.

When the bolus has been pushed back to the isthmus of the fauces, the first stage of deglutition is completed: the voluntary effort now ceases, and a series of complicated and involuntary movements are instituted by which the food is carried into the œsophagus. Upon analyzing these movements it is found that when the bolus enters the isthmus of the fauces the pendulous veil of the palate is suddenly drawn upward and obliquely backward and made tense by the action of the levator and tensor palati muscles. The bolus, striking against this tense and sloping roof, is deflected downward toward the bottom of the pharyngeal cavity. At the same instant the posterior wall of the pharynx advances, and the constrictor muscles, commencing to contract from above downward, grasp the food and soft palate and by a rapid peristaltic action strip the bolus into the œsophagus. During their contraction the constrictor muscles tend to draw up the inferior and anterior portions of the pharynx, shortening its vertical diameter, and aiding in this way the entrance of the food into the œsophagus.

While the food is passing downward through the pharynx, the larynx is observed to ascend abruptly under the base of the tongue, to remain there for a moment, and then immediately return to its normal position. This sudden elevation of the larynx is brought about by the contraction of the stylo-hyoid, genio-hyoid, mylo-hyoid, and anterior belly of the digastric muscles acting upon the hyoid bone from the inferior maxilla as a fixed point. While the food is passing through the pharynx it is seldom, under normal conditions, that any portion of it ever finds its way into either the posterior nares or the larynx, the openings of these cavities being fully protected by appropriate means. The posterior nares are guarded against the entrance of the food by a septum partially formed by the pendulous veil of the palate when it is drawn upward and backward, meeting the advancing wall of the pharynx. This septum is completed by the posterior half-arches, the palato-pharyngei muscles, when they contract: they then approximate each other in the upper part of their extent, while the uvula occupies the narrow space left between them. By these means the opening between the nose and pharynx is completely closed, and the bolus is directed downward through the space between the inferior portions of the posterior half-arches. That this is the action of the palatal structures during deglutition is well shown by those cases where from disease—*e. g.* diphtheritic paralysis, ulcerations, etc.—they are prevented from performing their natural functions. Under such circumstances, the naso-pharyngeal cavities not being completely closed, portions of the food, and particularly liquids, are regurgitated into the posterior nares. The larynx, equally with the nares, is protected against the entrance of foreign bodies during deglutition under normal conditions. That this accident occasionally hap-

pens, giving rise to severe spasmodic coughing, and even in extreme cases to suffocation, is abundantly shown by the records of clinical medicine. Usually this does not occur, as the act of inspiration by which particles of the food might be sucked into the air-passages is completely suspended and the edge of the glottis closed by the contraction of the pharyngeal muscles.

In addition, the larynx is still further secured by its ascent under the base of the tongue and by the action of the epiglottis. In this situation the glottis is thoroughly covered over by the soft base of the tongue. By this means alone sufficient protection is afforded the larynx against the entrance of food, with the exception perhaps of liquids; for even when the epiglottis is removed but little difficulty is experienced in swallowing, either by man or the inferior animals, if the ascent of the larynx be not interfered with.

Supplementing this provision, and intimately connected with it, is the action of the epiglottis. This structure, shaped somewhat like a leaf, is pliable, being composed of cartilage. It is attached to the anterior portion of the superior opening of the larynx, and projects upward behind the base of the tongue. The anatomical relations of the epiglottis would lead to the inference that when the larynx is elevated and the food passes backward it would be pushed down, and from its size would completely cover the laryngeal opening. That the epiglottis thus affords material protection to the larynx during swallowing has been fully established by the experiments of Longet made upon six dogs, in all of which it was completely excised, and by observations upon individuals in whom the structure or function of the epiglottis had been impaired by disease; for in every instance its excision in animals or destruction in the human subject has been followed invariably, even after an interval of months, by difficulty in deglutition, as shown by convulsive coughing; and especially is this the case in the swallowing of liquids. Solids and semi-solids are swallowed with much less discomfort, particularly if the attention be directed to the act.

The exalted sensibility of the mucous membrane lining the upper portion of the larynx assists in preventing the entrance of the food into its interior; for as soon as any portion of it, either liquid or solid, enters the supralaryngeal cavity, as is the case occasionally during an inspiratory effort, it at once excites a reflex spasmodic cough by which it is expelled. But if the sensibility be destroyed, as it is when the superior laryngeal nerves are divided, then portions of the food, especially liquids, find their way through the larynx into the trachea. The presence of the foreign body not being appreciated, the animal by making an inspiratory movement sucks the food into the trachea.

In the third stage of deglutition the food passes through the œsophagus by a reflex and involuntary movement, accomplished by a progressive contraction of its muscular walls.

The œsophagus is nine or ten inches in length, and extends from the lower border of the cricoid cartilage to a point opposite the ninth dorsal vertebra, where it expands into the stomach. Its walls are composed of an external or muscular and an internal or mucous layer, connected together by areolar tissue. The muscular coat consists of an

external layer of fibres running longitudinally and disposed in three bands, one in front and one on either side, and an internal layer arranged circularly in the upper part of the œsophagus and obliquely in its lower portion. Throughout the œsophagus the muscular fibres are of the striated variety and of a decidedly red color, with the exception of its lower fourth, where the fibres are much paler and of the non-striated variety. The mucous membrane is loosely attached to the muscular coat by areolar tissue. During the intervals of deglutition it is thrown into longitudinal folds, which disappear when the canal is distended, as it is by the passage of the food. It is covered by a layer of thick, squamous epithelium. Throughout its extent are scattered compound racemose glands which are particularly abundant at the lower end of the œsophagus. They secrete a glairy mucus which covers over the surface of the mucous membrane and facilitates the passage of the food.

When the food enters the upper portion of the œsophagus a slow peristaltic contraction from above downward takes place, by which it is pushed onward into the stomach. In this contraction the longitudinal fibres tend to shorten the length of the œsophagus and slip it over the bolus, while the circular fibres, contracting behind it, narrow the passage and force it onward. This constriction then travels downward and forces the food into the stomach, from which it is prevented from regurgitating by the firm contraction of the non-striated muscular fibres in the lower third of the œsophagus, which do not relax for from half a minute to a minute after the passage of the food.

Nervous Circle of Deglutition.

(Nerve-centre for deglutition in the medulla oblongata.)

Afferent or Excitor Nerves.

1. Palatal branches of fifth pair.
2. Pharyngeal branches of the glosso-pharngeal.
3. Superior laryngeal branches of pneumogastric distributed upon the pharynx.
4. Œsophageal branches of pneumogastric.

Efferent or Motor Nerves.

1. Pharyngeal branches of the pneumogastric, which are probably originally derived from the spinal accessory.
2. Hypoglossal, distributed to the lingual, sterno-hyoid, sterno-thyroid, and thyro-hyoid muscles.
3. Motor filaments of the inferior maxillary branch of the fifth pair supply elevator muscles of lower jaw and tensor palati.
4. Facial nerve, distributed to the digastric, stylo-hyoid, levator palati, azygos uvulæ, and probably the palato-glossus and palato-pharyngeus and the muscles of the lower part of the face.
7. Filaments of the recurrent laryngeal.
8. Branches of the cervical plexus uniting with the ascendens noni.

Deglutition is almost exclusively a reflex act throughout its entire extent, and requires for its inauguration only some stimulus to the sensitive mucous membrane of the mouth and fauces. The first stage of the process, though capable of being called forth by a voluntary effort, usually takes place involuntarily from inattention. The second and third stages are, however, involuntary and entirely reflex. They there-

fore require the presence of some stimulus to call them forth, such as the food, tickling the fauces, etc. When swallowing is induced voluntarily a small quantity of saliva is forced by the tongue into the fauces, which then acts as a stimulus. With the mouth perfectly free from saliva or any other stimulus deglutition is almost impossible. The nerves and centres concerned in this reflex act are shown in the preceding table.

Gastric Digestion.

After the food has passed from the œsophagus into the stomach it is there retained for a variable length of time, during which most important changes are induced in its physical and chemical composition. The disintegration of the food inaugurated by mastication and insalivation is still further carried on in the stomach by the solvent action of the acid fluid there present, until the entire mass has become reduced to a liquid or semi-liquid condition.

The stomach is that dilated portion of the alimentary canal intervening between the œsophagus and small intestine. When distended by food it is somewhat conical or pyriform in shape and slightly curved upon itself. It is situated transversely in the upper part of the abdominal cavity, extending on either side into the right and left hypochondrium. It is retained in position by its attachment to the œsophagus and by folds of peritoneum attached to its surfaces throughout their entire length. The stomach varies in diameter in different portions of its extent: the left extremity, the cardiac end, is much larger than the right extremity, the pyloric end. The opening through which the food passes into the stomach is known as the œsophageal or cardiac orifice; the opening by which it passes into the intestine is known as the pyloric orifice. Between these two orifices the stomach along its upper border presents a curve four or five inches in length, named the lesser curvature; along its lower border it presents a much larger curve, which is very convex, and known as the greater curvature. The dimensions and capacity of the stomach, its form and position, undergo considerable periodical variations according to the extent to which it is distended by the food. When moderately filled it measures in its long diameter from thirteen to fifteen inches, and in its transverse diameter from four to five inches. Its capacity varies from five to seven pints. When empty its walls are collapsed and partly in contact. During the period of digestion its position becomes changed: the greater curvature becomes raised upward and is directed against the anterior wall of the abdomen.

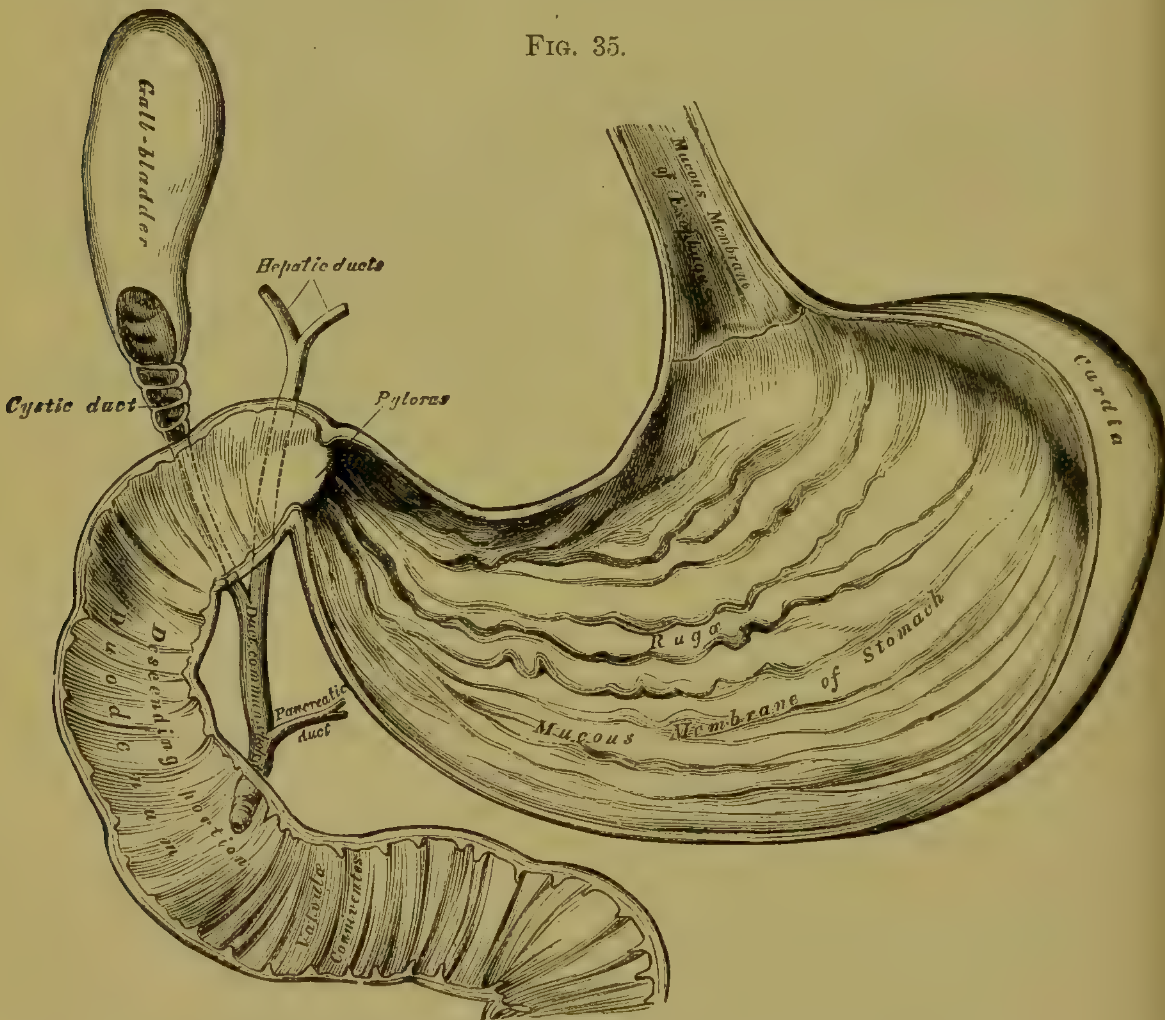
The walls of the stomach are formed by three distinct coats united together by areolar tissue, and are named from without inward as the peritoneal, muscular, and mucous. The layer of areolar tissue between the mucous and muscular coats is regarded by some anatomists as a separate and distinct coat.

The external or peritoneal coat is formed by a reduplication of the general peritoneal membrane. It is thin and transparent, and measures on the average about the $\frac{1}{250}$th of an inch in thickness. It is attached to the entire surface of the stomach, with the exception of its greater

and lesser curvatures. The free surface of the external coat is smooth and moist and covered by a layer of pavement epithelial cells. This smooth and lubricated surface of the stomach allows of free movement over the other viscera and the walls of the abdomen without any friction.

The middle or muscular coat consists of three distinct layers of fibres, named, from their direction, the longitudinal, circular, and oblique. The longitudinal fibres are most abundant along the lesser curvature, and are continuous with those of the œsophagus; over the rest of the stomach they are very thinly scattered, but toward the pyloric orifice they become more numerous and form a tolerably thick layer, which becomes continuous with the fibres of the small intestine. The circular fibres form a complete layer of the entire surface of the organ, with the

FIG. 35.



The Mucous Membrane of the Stomach and Duodenum, with the Bile-ducts.

exception of the great pouch; they pass concentrically around the body of the organ, and as they approach the pylorus become more closely arranged, forming annular rings. At the pyloric opening the fibres are crowded together and constitute the pyloric muscle, which projects some distance into the interior of the stomach; when contracted it forms a sphincter muscle, which closes the opening into the small intestine. The oblique fibres are continuous with the circular fibres of the œsophagus:

they are most numerous over the cardiac extremity, but extend from left to right as far as the junction of the middle and last third of the greater curvature.

The internal or mucous coat is loosely attached to the muscular coat by a layer of areolar tissue. When the stomach is empty the mucous lining is thrown into longitudinal folds or rugæ, which, however, become obliterated when the organ is distended by food. The mucous membrane, though continuous with that of the œsophagus, presents an entirely different appearance. It is smooth, soft, and velvety, covered by a layer of mucous membrane, and of a pink hue from the presence of blood in the capillary vessels: it measures on the average about $\frac{1}{24}$th of an inch in thickness. The surface of the membrane is covered with regular columnar epithelial cells, each possessing a distinct nucleus and nucleolus.

The surface of the mucous membrane, when freed from mucus by carefully subjecting it to the action of a small stream of water and examined with the aid of a lens of low power, presents throughout innumerable depressions which are polygonal in shape, surrounded by slightly elevated ridges; they vary in size from the $\frac{1}{200}$th to the $\frac{1}{100}$th of an inch in diameter, the largest being found toward the pyloric orifice. At the bottom of the polygonal depressions are to be seen small openings which are the orifices of racemose glands which exist in immense numbers throughout the entire extent of the mucous membrane. They are formed by an inversion of the basement membrane, and extend from the bottom of these depressions down to the submucous areolar tissue, and measure on the average the $\frac{1}{24}$th of an inch in length and the $\frac{1}{400}$th of an inch in diameter at their open extremity. In the cardiac extremity of the stomach the glands are of the racemose variety: commencing by a single orifice, the tubule pursues for a short distance a straight course, but soon becomes subdivided into several distinct tubules running parallel and closely crowded together. These tubules are lined in the upper fourth of their extent by columnar epithelium, similar to that covering the surface of the mucous membrane; but in their deeper portions the epithelial cells are of two distinct kinds. The most abundant are the small pale, spherical cells, finely granular and distinctly nucleated, which nearly fill the cavity of the tubule and constitute its regular cell lining. The other cells are larger, but fewer in number, have darker granules, and are found between the basement membrane and the central cells, giving to the tubule a nodular appearance. From their position they are known as parietal cells. In the pyloric portion of the stomach the tubules are not of this racemose variety, but belong to the simple or compound variety of follicles, and are lined throughout their depth with epithelium which is columnar or cubical in shape, and correspond to the central cells of cardiac glands. During the intervals of digestion the small cells lining the tubules of the cardiac end of the stomach do not stain readily with carmine, but while digestion is active these cells increase in size and number, and are visibly changed in their constitution, so that they will be readily stained by the carmine. These cells have been termed peptic cells, as they have been supposed to be connected with the production of the organic ferment pepsin (Fig. 36)

The differences in the minute anatomy between the two sets of glands in the same animal gave rise to the supposition that the cardiac glands only were concerned in the production of gastric juice, and the pyloric glands in the production of mucus. It is questionable, however, if this difference of function really exists to any marked degree, for if the pyloric portion of the mucous membrane be separated from the cardiac portion and macerated in acidulated water, a solution will be obtained which will possess digestive properties differing only in degree from a solution prepared from the cardiac end of the stomach. It is highly probable that the characteristic principles of the gastric juice are formed in all portions of the stomach.

Gastric Juice and the Methods of Obtaining it.—The various modifications which the food undergoes in the stomach are caused by the solvent action of the gastric juice. This fluid, secreted by the epithelial cells lining the tubules, is poured into the stomach during digestion and incorporated with the food by the contractions of the muscular walls. All our definite knowledge of the digestive process as it occurs in the stomach has been obtained from observation of persons having fistulous openings, corroborated by experiments made with normal gastric juice obtained from inferior animals and with artificial gastric juice made by adding glycerin to macerated mucous membrane, and subsequently adding hydrochloric acid to the glycerin filtrate.

The earliest observations made upon the properties and digestive action of gastric juice were made by Dr. Beaumont upon Alexis St. Martin, a Canadian *voyageur*, who, as the result of a gunshot wound, was left with a permanent fistulous opening into the stomach. This individual was in 1822 accidentally wounded upon the left side of the thorax by the discharge of a gun, the contents of the gun destroying a portion of the integument and muscles, breaking the fifth and sixth ribs, and in addition perforating the stomach. Under the skilful treatment of Dr. Beaumont the patient recovered. In two years the edges of the wound had entirely healed, but there remained an irregular opening into the stomach measuring about two and a half inches in circumference, which was usually closed from within by a fold of mucous membrane. The contents of the stomach were by this means effectually prevented from escaping through the opening. This valve, however, could be readily displaced by the finger and the interior of the stomach exposed to view. After the complete recovery of St. Martin, Dr. Beaumont during the years between 1825 and 1831 at intervals made numerous experiments upon the properties of the gastric juice and the digestibility of different articles of food, which, owing to the perfect health of the patient and the painstaking care with which they were performed, have furnished our most important definite knowledge concerning the action of the gastric juice. This fluid could always be readily obtained by introducing a gum catheter through the opening when the patient was in the recumbent position and lying upon the left side. The stimulation of the mucous membrane by the catheter was sufficient to cause a secretion of the gastric juice, which flowed through the tube in a small stream. In this way from half an ounce to one ounce and a half could be obtained. As a result of many observations it was

FIG. 36.

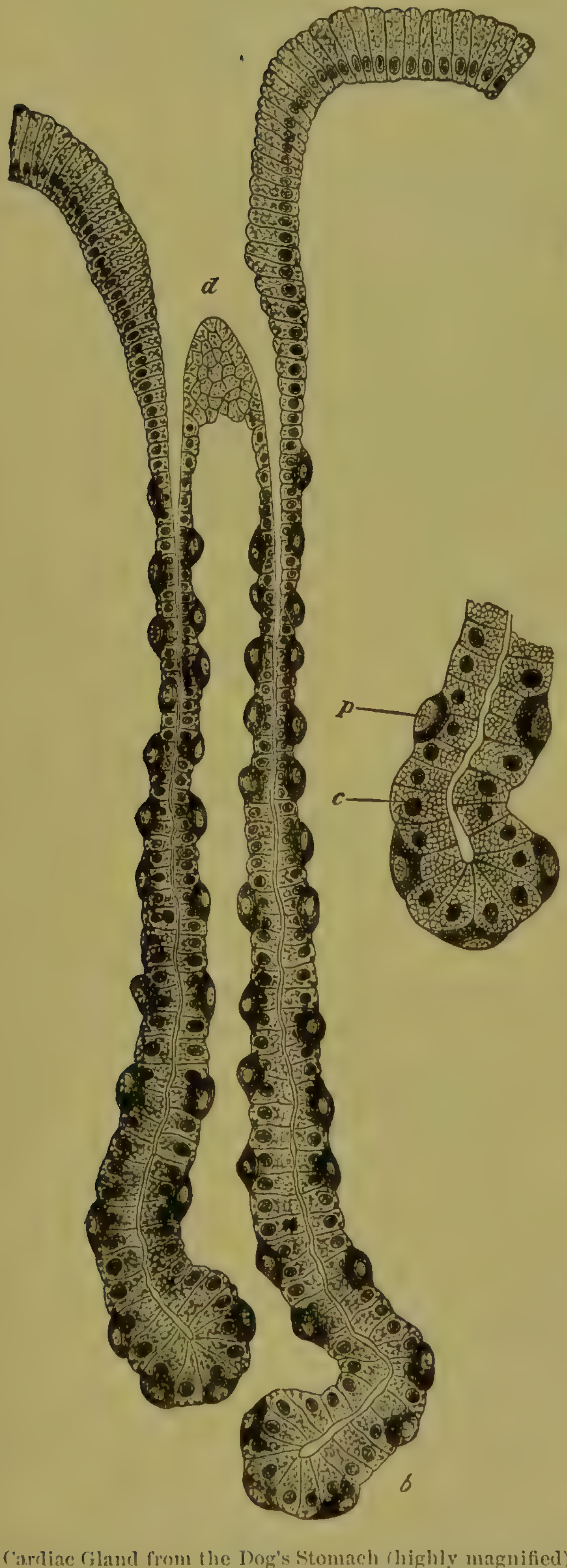


FIG. 37.

A Cardiac Gland of Simple Form, from the Bat's Stomach (osmic-acid preparation): *c*, columnar epithelium of the surface: *n*, neck of the gland with central and parietal cells; *f*, base or fundus, occupied only by principal or central cells, which exhibit the granules accumulated toward the lumen of the gland.

A Cardiac Gland from the Dog's Stomach (highly magnified): *d*, duct or mouth of the gland; *b*, base or fundus of one of its tubules. On the right the base of a tubule more highly magnified; *c*, central cell; *p*, parietal cell.

established that the digestion of the food is largely a chemical act due to the presence of an acid fluid secreted by the mucous membrane; that this fluid is secreted most abundantly after the introduction of food into the stomach; that different articles of food possess varying degrees of digestibility; and that the duration of digestion varies according to the nature of the food.

Since the establishment of permanent artificial openings into the stomach, first accomplished by Dr. Bassow in 1842 and in the following year by Blondlot, physiologists have been enabled to obtain and study in both the carnivorous and herbivorous animals outside of the body the properties and mode of action of gastric juice when kept at a proper temperature, and to compare the results thus obtained with those of Dr. Beaumont upon the gastric juice of Alexis St. Martin. In both instances the results are essentially the same. The operation for the establishment of a gastric fistula in a dog, the animal usually employed, is very simple. The animal should be thoroughly etherized and firmly secured upon a support. A longitudinal incision about two and a half inches in length should be made through the abdominal walls on the left side of the linea alba and over the greater curvature of the stomach. If the animal has been previously fed or the stomach distended with air, no difficulty will be experienced in seizing its anterior wall with blunt forceps and drawing it out through the opening in the abdomen. A small opening is then made with a bistoury in a direction parallel with the long axis of the stomach. A silver canula about one and a quarter inches in length, half an inch in diameter, and provided with a flange at either extremity is then introduced and secured in position by means of ligatures. The stomach is then replaced, and the edges of the abdominal wound drawn together and around the canula by sutures passing through the integument, muscles, and peritoneum. After the wound has healed, which it will do in a few days, the canula will be permanently retained in position. The contents of the stomach are prevented from escaping by closing the orifice of the canula with a cork. The wound usually unites without any peritonitis, and as the health of the animal is not impaired by the operation, it can be used from time to time for experimentation. When the gastric juice is to be collected, it is well to allow the animal to fast for several hours, so that the stomach may be free from the products of digestion. The cork is then removed and the mucous membrane gently stimulated with a feather or a catheter. In a few minutes the gastric juice will begin to flow down the side of the catheter. Small pieces of lean meat, somewhat hardened by boiling water, are also very effective in stimulating the secretion. By these means from one to two ounces may be obtained at any one time.

For the purposes of experimentation artificial gastric juice is just as effective as the natural secretion of animals, and is far more readily obtained. This method of study has been widely employed of late years by physiologists with most satisfactory results. To prepare an artificial juice the mucous membrane of the stomach of a pig recently killed is carefully freed from mucus by washing under a gentle stream of water. It is then dissected off from the muscular coat and rubbed

up in a mortar with powdered glass and water. After allowing it to stand for some hours and then filtering, a gastric juice will be obtained which is free from the products of digestion; and if acidulated with hydrochloric acid of 0.2 per cent. strength will possess marked digestive properties. Another method, largely employed, is to cut the mucous membrane into small pieces and place them in absolute alcohol for twelve hours: this will free them from water. After being filtered and dried the pieces of mucous membrane are placed under glycerin for several days, which will extract the organic ferment and acquire peptic properties: if a small portion be added to slightly acidulated water, an active digestive fluid will be obtained.

Mode of Secretion.—By the observations of Beaumont and the subsequent experiments of physiologists it was definitely ascertained that the secretion of the gastric juice is intermittent and not continuous—that it is only upon the introduction of food that the normal amount of the secretion is poured out. During the intervals of digestion the stomach is free from all traces of the juice. After the process of digestion has been completed the mucous membrane becomes pale and coated over with a layer of viscid mucus, which has a neutral or but faintly alkaline reaction. As soon as small portions of food are placed within the stomach, or even when it is irritated with a glass rod or by chemical means, the appearance of the mucous membrane changes: it becomes red and vascular, and in a few minutes, at the points of irritation, small drops of the secretion make their appearance; these gradually coalesce, forming still larger drops, which trickle down the sides of the stomach. The chemical reaction then changes and the mucous membrane becomes strongly acid.

Though the secretion of the gastric juice can be excited by these artificial means, owing to the local character of the irritation the amount secreted is but slight compared to the quantity poured out when the natural stimulant—viz. well-masticated food saturated with alkaline saliva—passes into the stomach from the œsophagus. Under such circumstances, the stimulus being general, the blood-vessels of the mucous membrane become flushed with blood, and enormous quantities are secreted from all portions of the stomach, this continuing at times for several hours. Highly-seasoned and savory foods are especially effective in exciting the flow of the gastric juice.

The *total amount* of gastric juice secreted in twenty-four hours under the stimulus of the food has been variously estimated, but the results obtained have been only approximative, as an exact estimate is not possible. The intermittency of the secretion, the fact that it is secreted most abundantly only in response to the stimulus of the food, the fact that it is again absorbed by the blood as well as by the food, render unsuccessful all attempts to accurately estimate the total amount secreted daily. The following estimates, though unreliable, show that the amount poured into the stomach daily is enormous, and far greater than that of any of the other digestive fluids. That the loss to the blood of so large an amount of fluid is not detrimental to its composition is because it is shortly again absorbed by the blood along with the products of digestion, and its normal composition thus maintained. Dr. Beaumont, by

stimulating only a portion of the mucous membrane with a gum catheter, was enabled to collect from the stomach of Alexis St. Martin two ounces of the secretion in from ten to fifteen minutes. Prof. Dalton states that he has often collected from the stomach of a medium-sized dog at the beginning of digestion 60 to 75 grammes (926 to 1057 grains) in the same period of time. Lehmann endeavored to estimate the quantity secreted by ascertaining the amount required to digest 1 gramme (15.4 grains) of dry albumen, and then multiplying this by the total amount of albumen consumed in twenty-four hours: he found that 1 gramme of albumen required 20 grammes (308 grains) of gastric juice for its complete digestion. Estimating the quantity of albumen consumed by the organism daily at 130 grammes (2000 grains), its complete solution would require 2600 grammes (40,000 grains) or $5\frac{1}{2}$ pounds of gastric juice. Prof. Dalton in his estimate employed a similar method: he ascertained the amount of gastric juice necessary for the solution of 1 gramme of lean meat containing 22 per cent. of solid matter to be 13.5 grammes (207 grains). According to this estimate, if a man consumes in his daily ration 453 grammes (6976 grains) of meat, it would require for its digestion about 6000 grammes (12 pounds). Bidder and Schmidt's estimate, based upon the quantity, 793 grammes (25.5 ounces), obtained during twelve hours from a dog weighing 33 pounds, places the quantity secreted by a healthy man in twenty-four hours at 6500 grammes (13 pounds).

The secretion of the gastric juice, called forth in response to the stimulus of the food, is a reflex act, taking place through and influenced by the central nervous system. Though the mechanism is but imperfectly understood, it has frequently been observed that mental emotions, such as fear and anger, by acting upon the vascular and secretory nerves will arrest and even vitiate the normal secretion. Under such circumstances the mucous membrane, as observed by Dr. Beaumont, may become red and dry or moist and pale. That the production of gastric juice is under the control of the central nervous system is evident from the results of experiment upon the pneumogastric nerve. If during digestion, when the peristaltic movements are active and the gastric mucous membrane is flushed and covered with an intensely acid secretion, the pneumogastric nerves be divided on both sides, the mucous membrane at once becomes pale, the secretion is arrested, the sensibility is lost, and the peristaltic movements become less marked. If after the division the peripheral end of the nerve be galvanized, no effects that are constant can be observed; but galvanization of the central end is followed by dilatation of the vessels and a flushed condition of the mucous membrane. It is evident, therefore, that during digestion afferent impulses are continually passing up the pneumogastrics to the medulla oblongata, which diminish the degree of contraction of the gastric blood-vessels. Efferent impulses in all probability descend through fibres of the sympathetic nervous system. After the division of all the nervous connections between the central nervous system and the stomach, however, a small quantity of the juice continues to be secreted for several days, this possessing a normal degree of acidity and digestive power. This has been attributed to the action of a local nervous mechanism (Meiss-

ner's ganglionic plexus) and to the direct action of the food upon the protoplasm of the secreting cells. Both explanations, are, however, very unsatisfactory.

Physical Properties and Chemical Composition of Gastric Juice.—The juice obtained from the stomach of the dog by means of a gastric fistula, and freed from mucus and other impurities by filtration, is a clear, colorless, slightly viscid fluid, with a constant and decidedly acid reaction. It is slightly saline and acid to the taste, and possesses a well-marked sour odor. The juice obtained from the human stomach possesses essentially the same characteristics. The specific gravity of that obtained from the stomach of Alexis St. Martin was found by different observers to range from 1005 to 1009: that obtained from lower animals has usually a somewhat higher specific gravity.

One of the most remarkable properties of gastric juice is its power of resisting putrefactive changes for a long period of time if carefully excluded from all atmospheric influences. Under such conditions it will not only undergo no apparent change in chemical composition, but will lose none of its digestive power. It will prevent, and even arrest, putrefactive changes in organic substances. In this respect it markedly differs from the saliva and pancreatic juice, which readily become decomposed and possess but slight power of preventing similar changes taking place in organic matter. Prof. Flint states that a specimen of gastric juice obtained from a dog and kept in a well-stoppered bottle presented no putrefactive odor nor suffered any change after a period of thirteen years.

The chemical composition of the gastric juice has never been satisfactorily determined, owing probably to the fact that the secretion as obtained from fistulous openings has not been absolutely normal. The following table represents the composition of a specimen obtained by Schmidt from the stomach of a woman who had a fistula, but who was nevertheless in good health:

Composition of Human Gastric Juice.

Water	994.404
Pepsin	3.195
Hydrochloric acid	0.200
Calcium chloride	0.061
Sodium chloride	1.465
Potassium chloride	0.550
Calcium phosphate, Magnesium phosphate, Iron phosphate	0.125
	1000.000

The organic principle present in the gastric juice, and upon which its digestive power depends, has been named pepsin. It is a non-diffusible, organic, nitrogenized ferment soluble in water and glycerin. It is capable when associated with hydrochloric acid of transforming the albuminous matters of the food into peptones. Pepsin is produced by the secretory activity of the gastric glands, and more especially by the central cells of the glands, which during digestion become swollen, cloudy, highly granular, and which stain readily with carmine. Toward the

end of digestion they again diminish in size and return to their original condition. It is said that when the cells are swollen and granular they are rich in pepsin, and contain but little when pale and small in the intervals of digestion. Similar changes have been observed in the cells of the so-called mucus-glands of the pyloric portion of the stomach during digestion, and it is not unlikely that pepsin is produced by them also, as an acidulated infusion of the mucous membrane of this portion of the stomach possesses digestive properties. Pepsin may be obtained in a moderately pure state from the glycerin extract of the mucous membrane of the pig's stomach after the method recommended by Brunton. The pieces of mucous membrane, after being freed from their water by immersion in absolute alcohol for twenty-four hours, are dried and covered with glycerin for several weeks. The glycerin is then filtered off, first through linen and then through paper, and the filtrate treated with an excess of absolute alcohol, when a flocculent precipitate will take place. This precipitate, if washed with alcohol, is readily dissolved in water, and contains the ferment in a moderately pure condition. If acidulated with hydrochloric acid in the proportion of 0.2 per cent., the solution will digest fibrin with considerable rapidity. Pepsin may therefore be regarded as a product of the mucous membrane, and especially of the central cells of the glands. It is manufactured and accumulated by them during the intervals of digestion as a part of the general nutritive process.

The presence of an acid in the gastric juice which gives to it its well-marked acidity is so prominent a characteristic that it has been recognized by all observers; but notwithstanding the careful analyses made by the most competent physiological chemists, employing different methods, there has been the greatest difference of opinion as to the nature of this acid, and more particularly as to whether it be organic or mineral. Among the earlier observers, Prout and Dunglison entertained the view that hydrochloric acid gave the acidity to the secretion, and that it existed in a free condition. This was subsequently denied by Lehmann, Bernard, F. G. Smith, and others, who after a series of experiments came to the conclusion that, though hydrochloric acid could be obtained by the method of distillation, it was due to the decomposition of the chloride of sodium or calcium. They regarded lactic acid as the source of the acidity, partly basing their view upon the fact that when oxalic acid is added to gastric juice a precipitate of oxalate of lime is produced—a reaction which does not belong to hydrochloric-acid solutions even when present in very small quantity. Since the careful and now generally received analysis of the gastric juice by Schmidt it has been admitted that the acid ingredient is hydrochloric acid, and if not existing in a free condition at least loosely combined with pepsin. Prof. Graham also examined a specimen of gastric juice by the method of dialysis and found hydrochloric acid. Recently, Richet confirmed this view by the employment of an entirely different method based upon the comparative solubility of lactic and hydrochloric acids in ether, the former being exceedingly soluble, the latter but slightly so. After a careful examination of the gastric juice he concludes that it contains hydrochloric acid almost

exclusively, though a small percentage of lactic acid may also be present—as a result, probably, of some decomposition of the food. Nevertheless, hydrochloric acid is not absolutely necessary, for if it be neutralized, and then the acidity restored by the addition of acetic, sulphuric, or nitric acid, the gastric juice will again acquire peptic powers, though in a less degree.

The origin of the acid is difficult to explain. During the intervals of digestion the mucous membrane is neutral in reaction, but as soon as the digestive process is established the acid is secreted and poured into the stomach along with the water and saline constituents. The mode of its production is imperfectly understood, but there is evidence that it is the product of the secretory activity of the glandular cells, and manufactured from materials furnished by the alkaline blood. It is a well-established fact that during digestion the production of so large an amount of acid increases the alkalinity of the blood to such an extent that the urine, usually acid, becomes neutral or even alkaline in reaction. Moreover, the immediate production of the acid takes place only near the orifices of the glands, for it is only upon its surface that the mucous membrane exhibits an acid reaction: in its deeper portion it is neutral or alkaline. This can be shown by the experiment recommended by Lauder Brunton: After killing a pigeon, dissect off the mucous membrane from the muscular layer of that portion of the alimentary canal lying between the gizzard and crop, the proventriculus. Remove the deep portions of the glands with a pair of scissors and test with litmus-paper. It will be found that the cut surface is neutral or faintly acid in reaction, while the inner surface is strongly acid. The acidity of the free surface only can also be shown by first injecting into the jugular vein of a rabbit a solution of ferric lactate, and then a solution of potassium ferrocyanide. This experiment is based upon the fact that it is only in the presence of an acid that these two salts will unite to form the ferrocyanide of iron, the Prussian blue. Upon opening the stomach about an hour afterward the free surface of the mucous membrane is found to be deeply colored with the Prussian blue. This is confined to the surface, for upon making a transverse section of the membrane it will be seen that the deeper portions are entirely colorless. When the two solutions were exuded from the blood-vessels, it was not until they approached the surface that they came in contact with the free acid and united. The hydrochloric acid is therefore a product of the mucous membrane, and formed only during the activity of the digestive process. That the gastric juice may exert its complete digestive power, it is indispensable that the two characteristic principles, pepsin and hydrochloric acid, should coexist; for in the absence of either the transformation of the albuminous principles will not be accomplished. It is exceedingly probable that the two principles are loosely combined, forming the new compound, hydrochloro-peptic acid.

Physiological Action of Gastric Juice.—In the study of the physiology of gastric digestion as it takes place under normal conditions, it is important to bear in mind that the food introduced into the stomach is a very heterogeneous compound, containing nutritious principles associated with a large amount of innutritious material, from which the

former must be separated before they can be acted upon by the gastric juice—that the albuminous principles thus separated must undergo a change in chemical composition before they can be absorbed and assimilated. The gastric juice has in reality a twofold action: 1st, a physical action, by which the fibrous tissues of meats, the cellulose and hard parts of grain and vegetables, are dissolved away until the food is completely disintegrated and reduced to the condition of a thin fluid; 2d, a chemical action, by which the albuminous principles are transformed by the acid and pepsin into peptones or albuminose. When first freed from combination the albumens are generally insoluble and non-diffusible, belonging to the colloidal group of bodies and unable to pass through animal membranes. The gastric juice, however, modifies their chemical composition, rendering them soluble and diffusible, so that they can pass readily into the blood.

In the following table is a list of the more important foods, with their contained albuminous principles:

Food.	Albuminous Principle.
Flesh of animals	Myosin, syntonin.
Curd of milk and cheese	Casein.
White of eggs	Egg-albumen.
Yelk of eggs	Vitellin.
Blood contained in meat	Fibrin, globulin.
Grain of wheat and other cereals	Gluten.
Succulent vegetables and fruits	Vegetable albumen.
Juices of plants, cereals, etc.	Vegetable fibrin.
Peas, beans, lentils, etc.	Legumin, vegetable casein.

Upon *meat* the gastric juice has a decidedly disintegrating action, the nature of which has been determined by suspending it in an acidulated infusion of the mucous membrane of the stomach and comparing the changes with those observed in man and the lower animals. If small cubes of meat be placed in gastric juice for several hours, it will be found that a considerable portion of it has become dissolved. The fluid will have become turbid and increased in density. Under these conditions the gastric juice seizes upon and dissolves the connective tissue which holds the muscular fibres together. The structural composition of the fibres is then destroyed, the sarcolemma is dissolved, and the whole is reduced to the condition of a grumous, pultaceous mass. When examined microscopically the muscular fibres are found to be in a broken state, softened down, and the transverse striations very indistinct. The muscle substance is then in a condition to be transformed into peptone. The complete digestion of meat is not accomplished in the stomach, but is subjected to further change by the fluids it meets with after it passes into the small intestine. *Myosin* is the chief albuminous constituent of muscular fibre. When coagulated it is an amorphous substance insoluble in water.

Milk undergoes coagulation in the stomach in from ten to fifteen minutes, owing to the precipitation of the casein, which subsequently becomes dissolved. The precipitate is in the form of soft flocculi easily converted into peptone. This change has been attributed to the influence of a special ferment, as it will take place even when the acid of the stomach has been neutralized. Pure pepsin does not possess the power of coagulating

milk. The *casein* differs from other forms of albumen in not being coagulable by heat, in being precipitated by organic acids, and in having a large quantity of phosphate of lime bound up with it.

The *white of egg* in a raw or slightly boiled condition is readily digested by the gastric juice in from one to two hours. It undergoes disintegration by a solution of the delicate membranous cells in which the soluble albumen is contained. This process can be facilitated by previously breaking up the cells by agitating with water. When the albumen has been firmly coagulated by boiling, its solution becomes much more difficult. The gastric juice first attacks the surface of the coagulated masses, and gradually penetrates their interior. They are thus softened, and under the influence of the movements of the stomach are completely dissolved. *Egg-albumen* is the main ingredient of white of egg. It is soluble in water, from which it can be precipitated by strong alcohol and coagulated by heat and nitric acid. The *yelk of the egg* contains a large percentage of fatty matter held in suspension by the albuminous substance *vitellin*, which is a modified form of the egg-albumen.

The *blood* of meat does not form an important article of diet. It contains *fibrin* and *globulin*, two albuminous principles readily dissolved by the gastric juice.

Wheat is seldom used in its entire state as food, but is made up in the form of bread, which is mainly a combination of an albuminous principle, gluten, and hydrated starch. By being subjected to the action of heat its digestibility is very much increased, and when incorporated with gastric juice, either in the stomach or test-tube, it readily undergoes disintegration and liquefaction. The starch-granules are ruptured and set free, while the *gluten* is transformed into a soluble peptone.

The *vegetable tissues* after being subjected to the boiling process are readily acted upon by the gastric juice, and undergo the same disintegrating process as the muscular tissues. The cellulose and woody fibre are dissolved away, thus freeing the albuminous, starchy, and oleaginous principles from association with the innutritious portions. The albuminous principles contained in vegetables are nearly identical with those of the animal tissues, but are far less abundant. *Vegetable albumen* is contained in wheat and most of the cereals and the juices of most vegetables. It can be precipitated by heat. *Vegetable fibrin* undergoes spontaneous coagulation like animal fibrin: it is present in the cereal seeds and in the juices of grapes and most vegetables. *Legumin* or *vegetable casein* can be obtained from peas, beans, leguminous seeds, etc., and is supposed to have the same chemical and physiological properties possessed by animal casein. As nutritive principles the albumens derived from the vegetable world possess a value equal to that possessed by those derived from the animal world, as they differ but slightly in their chemical composition.

Action of the Gastric Juice on Albumen.—All of the albuminous principles which are taken into the stomach with the food are insoluble in water, non-diffusible, and incapable of being assimilated. When subjected to the action of gastric juice, however, they are transformed into new substances, which are soluble, highly diffusible, and easy of

assimilation. The nature of this change and the respective influences which the pepsin and acid exert can be easily studied by suspending small pieces of coagulated fibrin in artificial gastric juice, which for experimental purposes is as efficacious as the normal secretion, and differs from it in no essential respect. For this purpose the glycerin extract when acidulated with a 0.2 per cent. solution of hydrochloric acid is probably the best. The most suitable form of albumen for exhibiting the digestive power of gastric juice is coagulated fibrin, which can be readily obtained from blood by whipping. It must be thoroughly washed under a stream of water until it is perfectly free from blood.

To demonstrate the respective parts played by the pepsin and acid in the digestion of albumen, small quantities of the glycerin extract of pepsin and 0.2 per cent. solution of hydrochloric acid are placed in separate test-tubes. Small pieces of fibrin are then placed in the two solutions, and kept at a temperature of 104° F. for one or two hours. At the end of this time the fibrin in the pepsin extract will have undergone no change, while the fibrin in the acid solution will have become swollen, transparent, easily broken up, and partially dissolved. If, then, the latter solution be carefully neutralized, the dissolved fibrin can be regained in the form of *acid-albumen* or *syntonin*. The formation of this substance appears to be the main action of the acid. But when the fibrin is placed in a test-tube containing both the acid and pepsin, and kept at the temperature of the body for several hours, it will likewise become swollen and transparent, and finally digested, forming a clear opalescent mixture, from which, however, no precipitate takes place either upon boiling or neutralization. This further change is due to the successive actions of the two ingredients. The first step in the process is due to the action of the acid alone, by which the fibrin is transformed into *acid-albumen*, which can be shown by neutralization; the next step is a further transformation of the acid-albumen by the pepsin into *peptone*, which is soluble in both acids and alkalies, and not coagulated by heat. The extent to which digestion has taken place at any moment can be shown by the amount of precipitation that occurs upon the addition of either of these agents. Although the precipitate produced resembles ordinary acid-albumen, there is reason to believe that it differs from it in some respects, so that the name *parapeptone* has been suggested for it. All varieties of albumen are transformed into peptones by the gastric juice. Pepsin alone will not accomplish this result, but must be associated with an acid, which initiates the change. The intimate nature of this change is obscure, but as it will not take place except in the presence of water, it is not improbable that it consists in the assumption of water. As suggested by Prof. M. Foster, "Judging from the analogy with the action of saliva on starch, we may fairly suppose that the process is at bottom one of hydration."

The rapidity and effectiveness with which the gastric juice converts albumen into peptone depends largely upon the conditions in which it is placed and the degree of temperature to which it is subjected. When the albumen is finely divided, and consequently a great extent of sur-

face exposed to the action of the juice, the conversion takes place more rapidly than when it is imperfectly divided. A removal of the products of digestion as fast as formed is also a necessary condition for a continuance of the process. The temperature also has an important influence upon the activity of the gastric juice. At 32° F. the action is almost entirely suspended, but gradually increases with an increase of temperature up to that of the living body (101° to 104° F.), when it reaches its maximum: beyond this point its activity again diminishes until the temperature reaches 210° F., when the function of the pepsin is entirely destroyed. All of these conditions are completely realized in the human stomach. When the food has been thoroughly masticated and incorporated with saliva, there is an abundant secretion of a gastric juice containing the normal percentage of hydrochloric acid and pepsin; the products of digestion are removed as rapidly as they are formed; the rhythmical movements of the walls of the stomach turn over the food and bring fresh portions of it into contact with the gastric juice, while the temperature is that at which its activity is most pronounced.

Characters of Peptones.—The various products resulting from the action of the gastric juice upon the different albuminous principles have been termed *peptones.* These substances, though resembling each other in many respects, possess a different chemical composition, as shown by their reactions with chemical reagents. They also have some resemblance to the albumens from which they are derived, but can be distinguished from them by the following general characters—viz.:

1. They are exceedingly soluble in water, either hot or cold, and in acid and alkaline solutions.

2. They are not coagulable by heat or nitric acid.

3. They can be precipitated from neutral solutions by nitrate of mercury, tannic acid, nitrate of silver, iodine, chlorine, and chloride of mercury.

4. They are highly diffusible, passing rapidly through living animal membranes, the degree of diffusibility being proportional to the amount of water they contain. It has been demonstrated that peptones will diffuse about twelve times as rapidly as the albumens from which they have been derived.

5. They are assimilable by the blood. When injected into it they do not reappear in the urine, as is the case with albumen.

Upon *starch* itself gastric juice has no appreciable effect, and if taken into the stomach in the hydrated or cooked state passes into the intestine unchanged. On *fat* the gastric juice has no specific action, but when adipose tissue has been eaten the connective tissue and the albuminous vesicles are dissolved and the fat-globules set free. By the heat of the stomach they are converted into a liquid mass which floats over the contents of the stomach and passes through the pylorus unchanged. Neither *grape-sugar* nor *cane-sugar* suffers any change in the stomach, except when it contains an excess of mucus. Then cane-sugar is slowly transformed into glucose. The *inorganic principles* are slightly, if at all, modified by the gastric juice, as they are usually soluble in water and in a condition to be absorbed and assimilated.

The length of time the food remains in the stomach and the relative digestibility of different articles of food were carefully studied by Dr. Beaumont upon St. Martin, and, though the results obtained by him may not be absolutely correct viewed in the light of recent knowledge of the digestive process, yet in the main they have been corroborated by subsequent experiments upon animals. The fact that St. Martin several years after his accident was in all respects perfectly healthy, with good digestion, gives to these results a value not to be obtained by any other means. As a result of many observations, Dr. Beaumont came to the conclusion that the average length of time an ordinary meal, consisting of meat, bread, etc., remained in the stomach undergoing digestion was about three to three and a half hours, the duration of the process, however, being increased when an excessive quantity of food was taken or the quantity or quality of the gastric juice impaired by abnormal conditions of the system. As soon as the food has been liquefied by the gastric juice, that portion not absorbed by the gastric vessels passes into the intestines, and this continues for two or three hours until the stomach has become entirely empty.

Table showing the Digestibility of Various Alimentary Substances in the Stomach (Beaumont).

Articles of Diet.	Mode of Preparation.	Hours.	Min.
Milk	Boiled	2	00
do.	Raw	2	15
Eggs, fresh	do.	2	00
do. do.	Whipped	1	30
do. do.	Roasted	2	15
do. do.	Soft-boiled	3	00
do. do.	Hard-boiled	3	30
do. do.	Fried	3	30
Custard	Baked	2	45
Codfish, cured dry	Boiled	2	00
Trout, salmon, fresh	do.	1	30
do. do. do.	Fried	1	30
Bass, striped, do.	Broiled	3	00
Flounder, do.	Fried	3	30
Catfish, do.	do.	3	30
Salmon, salted	Boiled	4	00
Oysters, fresh	Raw	2	55
do. do.	Roasted	3	15
do. do.	Stewed	3	30
Venison steak	Broiled	1	35
Pig, sucking	Roasted	2	30
Lamb, fresh	Broiled	2	30
Beef, fresh, lean, rare	Roasted	3	00
Beef-steak	Broiled	3	00
Beef, fresh, lean, dry	Roasted	3	30
do. with mustard, etc.	Boiled	3	10
do. with salt only	do.	3	36
do.	Fried	4	00
Mutton, fresh	Broiled	3	00
do. do.	Boiled	3	00
do. do.	Roasted	3	15
Veal, fresh	Broiled	4	00
do. do.	Fried	4	30
Pork-steak	Broiled	3	15
do. fat and lean	Roasted	5	15
do. recently salted	Raw	3	00
do. do.	Stewed	3	00
do. do.	Broiled	3	15
do. do.	Fried	4	15
do. do.	Boiled	4	30
Turkey, wild	Roasted	2	18
do. domesticated	Boiled	2	25
do. do.	Roasted	2	30
Goose, wild	do.	2	30
Chicken, full grown	Fricasseed	2	45
Fowls, domestic	Boiled	4	00
do. do.	Roasted	4	00
Ducks, domesticated	do.	4	00
do. wild	do.	4	30
Soup, barley	Boiled	1	30
do. bean	do.	3	00
do. chicken	do.	3	00
do. mutton	do.	3	30
do. oyster	do.	3	30
do. beef, vegetables, and bread	do.	4	00
do. marrow-bones	do.	4	15
Pigs' feet, soused	do.	1	00
Tripe, do.	do.	1	00
Brains, animal	do.	1	45
Spinal marrow, animal	do.	2	40
Liver, beeves', fresh	Broiled	2	00
Aponeurosis	Boiled	3	00
Heart, animal	Fried	4	00
Cartilage	Boiled	4	15
Tendon	do.	5	30
Hash, meat, and vegetables	Warmed	2	30
Sausage, fresh	Broiled	3	20
Gelatin	Boiled	2	30
Cheese, old, strong	Raw	3	30
Green corn and beans	Boiled	3	45
Beans, pod	do.	2	30
Parsnips	do.	2	30
Potatoes, Irish	Roasted	2	30
do. do.	Baked	2	30
do. do.	Boiled	3	30
Cabbage, head	Raw	2	30
do. do. with vinegar	do.	2	00
do. do.	Boiled	4	30
Carrot, orange	do.	3	13
Turnips, flat	do.	3	30
Beets	do.	3	45
Bread, corn	Baked	3	15
do. wheat, fresh	do.	3	30
Apples, sweet, mellow	Raw	1	30
do. sour, do.	do.	2	00
do. do. hard	do.	2	50

The relative digestibility of the different nitrogenized foods was also

made the subject of many experiments by Dr. Beaumont. After repeating and verifying his observations, made under all circumstances, he summed up his results in the preceding table, in which the mode of preparation and time required for the digestion of different articles is exhibited.

Movements of the Stomach.—During the active period of gastric digestion the muscular walls of the stomach become the seat of a series of movements, peristaltic in character, which aid the thorough incorporation of the gastric juice with the food. At first the movements are slight, but as soon as the stomach becomes distended they become more marked and vigorous, and continue, though with diminishing vigor, until all the food has been dissolved and passed through the pylorus into the intestine. These movements are wave-like in character, beginning at the cardiac orifice and passing along the great curvature toward the pylorus, and back again to their point of origin. At the same time the position of the entire organ becomes changed. It is drawn upward, and the greater curvature is directed against the abdominal walls, while the anterior face becomes superior. During the continuance of these movements the cardiac and pyloric orifices are kept almost constantly closed by the contraction of their sphincter muscles. When, however, the food has been liquefied, the pyloric orifice opens and the liquefied portion passes into the intestine. This relaxation of the pylorus takes place periodically until all the food has been dissolved and the stomach emptied of its contents. The peristaltic movements of the stomach were carefully observed by Dr. Beaumont in the case of St. Martin. This observer was enabled to see into the interior of the stomach and watch the direction of the peristaltic movements by following the course taken by a morsel of food. When it passed into the stomach from the œsophagus, the circular fibres, contracting, carried it toward the cardiac extremity, from whence it passed along the great curvature to the pylorus, and back again along the lesser curvature to the œsophageal opening. This passage of the food along the inner surface of the stomach occupies from two to three minutes. It has also been observed that during digestion the stomach is partially constricted and divided into a cardiac and a pyloric portion by the contraction of a band of transverse muscular fibres—a condition which is permanently observed in some of the lower animals.

Intestinal Digestion.

The changes which the alimentary principles undergo in the small intestine are probably the most important of the entire digestive process; for here the food that has been partially digested in the stomach is subjected to the solvent action of the intestinal and pancreatic juices and the bile, each of which exerts a transforming influence upon one or more substances and still further prepares them for absorption into the blood.

The small intestine is a convoluted tube measuring about twenty feet in length, an inch and a half in diameter, and extends from the pyloric portion of the stomach to the ileo-cæcal valve. Its convolutions are very

numerous, it is attached posteriorly to the spinal column and held securely in position by a double fold of the general peritoneal membrane termed the mesentery. The walls of the small intestine, like those of the stomach, consist of three distinct coats—viz. serous, muscular, and mucous.

The serous coat is the most external of the three, and is a reflection of the general peritoneal membrane. It almost completely surrounds the intestine throughout its entire extent, a small portion along one border only being free. In its most superior portion also the serous coat is partially wanting. Its surface is smooth and glistening, and covered with a serous fluid, which permits a free movement of the intestines over each other without friction.

The muscular coat surrounds the entire intestine: it is thickest in the upper portion, gradually becoming thinner in the lower portion. It is composed of non-striated muscular fibres which are pale in color. The muscular coat consists of two layers of fibres: 1, an external or longitudinal set, and 2, an internal or circular set. The longitudinal fibres are most marked at that border of the intestine free from the mesenteric attachment, though they form a thin layer completely surrounding the intestine. The circular fibres are much more numerous, and are thicker than the longitudinal fibres, and completely encircle the bowel throughout its entire extent. These are the fibres which are mainly operative in the production of the vermicular movements of the intestine by which the food is carried from above downward.

The mucous coat presents a peculiar soft and velvety appearance, on account of its being covered with small processes termed *villi.* In the intervals of digestion it is of a pale color, but as soon as digestion commences it assumes a deep-red hue, due to its increased vascularity. Throughout its entire extent, with the exception of the inferior portion of the ileum, the mucous membrane presents a series of transverse folds called the valvulæ conniventes, or the valves of Kerkring. These folds vary from one-quarter to one-half an inch in width, and extend one-half or two-thirds of the distance around the interior of the bowel. Each valve consists of two layers of the mucous membrane, and, being united together by fibrous tissue, are permanent structures. From their immense numbers they must greatly increase the extent of the mucous membrane exposed to the food, and retard to some extent its passage through the intestine.

The villi are the small conical or club-shaped elevations of the mucous membrane which give to it the soft and velvety appearance which it presents. They are best seen after the mucous membrane has been freed from mucus by gently washing it under a stream of water. They are exceedingly numerous, being present everywhere from the pylorus to the ileo-cæcal valve: their length is, on the average, the $\frac{1}{24}$th of an inch and their breadth the $\frac{1}{240}$th of an inch. The villi are formed by an elevation of the mucous membrane, and are covered externally by a layer of columnar cells. Internally they are exceedingly vascular. The blood-vessels which enter at their base by from four to six branches are distributed through their interior, and ultimately unite to form veins.

which emerge from the villus as a single trunk. Each villus also contains a lacteal vessel, which in all probability originates as a single expanded blind extremity or several such extremities. These structures are imbedded in an amorphous matter in which are also found non-striated muscular fibres, and possibly nerves.

The entire intestine is arbitrarily divided into three portions, which, however, have no distinct lines of demarcation—viz. the duodenum, the jejunum, and the ileum. The duodenum—so called from having the length of the breadth of twelve fingers—measures from ten to twelve inches in length and from one and a half to two and a half inches in width. It is therefore the widest portion of the small intestine. In its course it presents a curve which has been described by anatomists as consisting of a superior, an ascending, and a transverse portion. It is this portion of the intestine into which the pancreas and liver discharge their secretions. The jejunum includes the upper two-fifths of the intestine, while the ileum—so called for its numerous convolutions—includes the remaining three-fifths. There is no well-defined limit between the jejunum and ileum, though the anatomical characters of the upper part of the former are somewhat different from those of the lower portion of the latter.

The *glandular apparatus* by which the intestinal juice is elaborated consists of—1, the glands of Brunner; 2, the follicles of Lieberkühn, or the intestinal follicles; 3, the solitary glands; 4, the agminated glands, or Peyer's patches.

The *glands of Brunner* are peculiar to the duodenum, and are most thickly set in the upper half of its extent. They are small rounded compound glands situated beneath the mucous membrane, and open upon its free surface by a short, wide duct. They measure about the one-tenth of an inch in diameter. In structure they are true racemose glands, consisting of minute lobules clustered around the termination of a central excretory duct which opens into the intestinal cavity. The duct and lobules are lined by a layer of nucleated epithelium. The secretion elaborated by these glands is clear and viscid, and alkaline in reaction. It contains no structural elements, and its chemical composition is unknown.

The *intestinal follicles*, or the *follicles of Lieberkühn*, are distributed throughout the entire mucous membrane of the intestinal tract in enormous numbers. They are found everywhere between the villi. In the neighborhood of the agminated glands they are arranged in rings which completely surround the gland. These follicles, formed mainly by an inversion of the mucous membrane, are usually single, but are occasionally bifurcated. They open by a small orifice upon the free surface of the mucous membrane while their attached extremity is closed. These tubules vary in length, but measure, on the average, the $\frac{1}{100}$th of an inch and in breadth the $\frac{1}{400}$th of an inch. Their walls are exceedingly thin, being formed of a delicate basement membrane and lined by a layer of columnar epithelial cells. The follicles of Lieberkühn constitute a most important glandular structure, secreting a clear viscid fluid which constitutes the chief portion of the intestinal juice.

The *solitary glands* are small, round white bodies found throughout the mucous membrane in variable numbers. They are closed vesicles, containing in their interior a semifluid substance composed of granular matter and cells.

The *patches of Peyer* are formed by the aggregation of the solitary glands united together by well-developed connective tissue. They are from half an inch to three or four inches in length, are oblong in shape, and are found most abundantly in the lower part of the ileum. Their vesicles are also closed, and contain a semifluid albuminous substance, cells, and numerous blood-vessels. Their function in digestion is unknown, but it is not unlikely that they secrete a fluid which is exuded upon the surface of the mucous membrane.

Intestinal Juice.—The intestinal juice, though composed of all the secretions of the glandular structures, consists mainly of the secretion of the follicles of Lieberkühn. Owing to its admixture with other fluids, and the profound disturbance of the digestive function caused by the production of fistulous openings, this fluid has been rarely obtained in a state of purity or in sufficient quantity for experimental purposes. Its physiological properties and chemical composition are therefore but imperfectly understood. Various attempts have been made by physiologists, by the employment of different methods, to obtain this secretion for examination. The method employed by Bidder and Schmidt was first to ligate the pancreatic and biliary ducts, so as to prevent the entrance into the intestine of the pancreatic juice and the bile, and then subsequently establish a fistulous opening some distance below. They employed cats and dogs for this purpose. The fluid they obtained was clear, viscid, and alkaline in reaction, and possessed the power of transforming hydrated starch into glucose. Meat and albumen were also partially digested, while fat was emulsified.

Colin experimented upon horses, and employed a different method. While the animal was in full digestion he made an incision into the abdominal cavity and withdrew from four to six feet of the small intestine. After freeing it from all its contents by stripping it from above downward with the fingers, a large loop was isolated by clamping it at either end with two covered metallic clamps applied in such a manner as to keep the mucous surfaces in contact, but not to injure the intestinal tissues. The loop was then returned to the abdomen, and after half an hour the animal was killed and the contents of the intestine between the clamps collected. The fluid obtained in this way was clear, of a yellowish tint, alkaline in reaction, and of a saline taste, and its specific gravity 1010. The average amount which accumulated in this time was three to four ounces. According to the analysis made by Lassaigne, it was composed largely of water, an albuminous substance, four and a half parts per thousand, and inorganic salts. These observations were made most carefully, but it is questionable if the juice thus obtained was a perfectly normal secretion. Colin found that it was capable of transforming starch into sugar and emulsifying fatty substances, though it is doubtful if the latter property was due to the pure juice. An intestinal fistula was first established by Thiry, and the juice obtained

in a perfectly pure state. The method employed by him was very successful, and it has been adopted and somewhat modified by subsequent observers. An incision was made through the abdominal walls of an animal and the intestine seized and divided at two places about seven inches apart, great care being taken not to injure the mesentery or blood-vessels. The continuity of the intestinal canal was then restored by uniting its divided ends together by means of sutures. The short portion of the intestine thus removed from its connections was closed up at one extremity by sutures so as to form a cul-de-sac, while the other was attached to the margin of the abdominal incision. Being supplied with blood-vessels, its nutrition was maintained and a normal secretion elaborated by the glands. The secretion obtained in this way was capable of converting starch into sugar and partially digesting albuminoid substances.

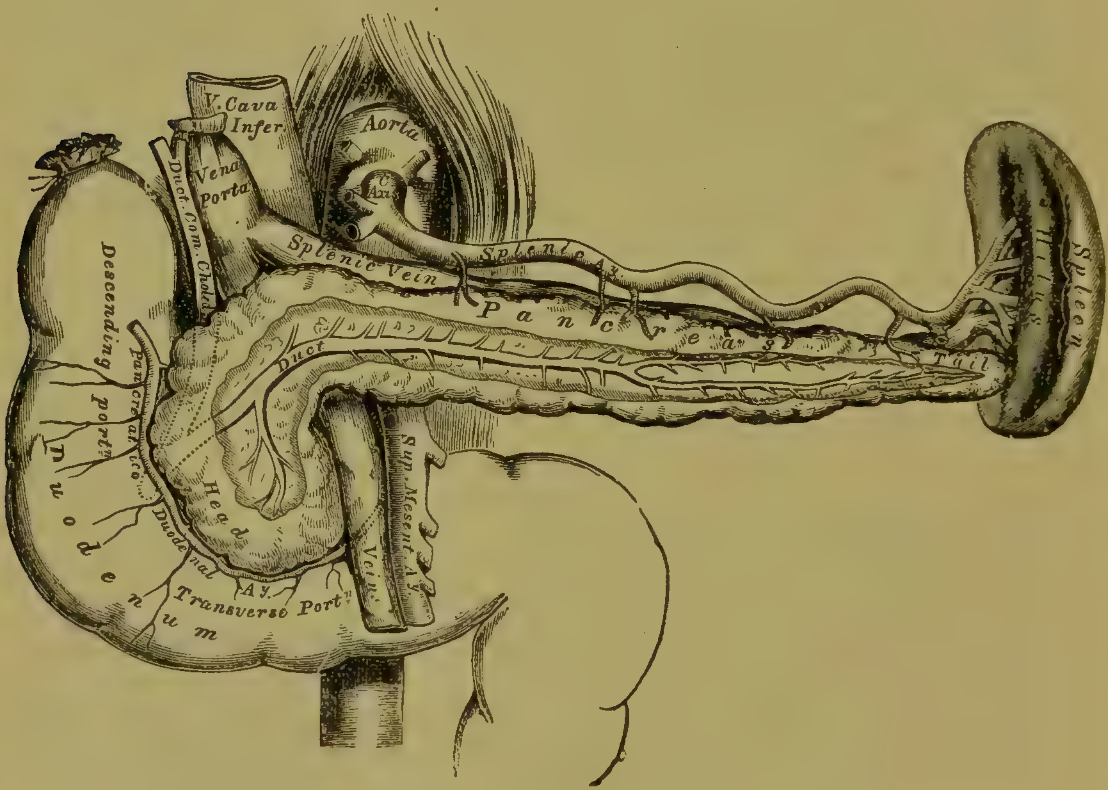
The results obtained as to the physiological properties of the intestinal juice by experiments upon animals have been in some respects verified by the observations of Prof. Busch upon a woman suffering with an intestinal fistula. This patient, æt. 31, was gored by a steer, the horn penetrating the abdominal walls between the umbilicus and pubis, with the result of establishing two contiguous openings and dividing the intestinal canal in its upper third. The opening in the abdominal wall communicated with the openings into the intestine. All nourishment that was taken into the stomach passed out through the upper opening without being absorbed and only partially digested. As a natural result, the woman's health declined on account of the partial starvation to which she was subjected. With the introduction of prepared and partially digested food into the lower portion of the intestine her health very materially improved. Taking advantage of the opportunity, Prof. Busch made a series of experiments with a view of determining the physical properties and physiological action of the intestinal juice upon the different alimentary principles. He was enabled to obtain but small quantities at a time, but it invariably resembled that obtained from animals, being clear, viscid, and alkaline in reaction. Its chemical composition was essentially the same, consisting of water, albuminous matter, and inorganic salts.

The lower two-thirds of the intestine being entirely free from both the pancreatic juice and bile, and containing only the intestinal juice, afforded an excellent opportunity for studying the effects of this secretion upon different articles of food. Busch introduced various articles of food into the lower opening, which were carried from above downward by the vermicular movements. As they were subjected to the action of the intestinal juice alone, it was evident that any change they would undergo could only be attributed to the action of this fluid, and the extent to which they had been dissolved could be determined by a careful examination of the feces. As the result of numerous observations he concluded that when starch, either in the raw or hydrated condition, was placed in the intestine, it was completely transformed into glucose and absorbed, no portion of it ever appearing in the feces; that cane-sugar was unchanged, the intestinal juice being incapable of transforming it into glucose; that albuminous matters were dissolved to a

slight extent; and that the fats were discharged from the body without having undergone the slightest emulsification. The experiments of Busch were most carefully conducted, and as his results are reliable, they represent the state of our knowledge of the properties of the physiological action of the intestinal juice.

Pancreatic Juice.—The pancreas is a long, flattened gland situated deeply in the abdominal cavity, lying just behind the stomach. It is divided into a body and a greater and lesser extremity. The greater extremity, or head, is directed toward the right, where it is embraced by the curve of the duodenum; the lesser extremity is directed toward the left and extends to the spleen. The pancreas measures from six to eight inches in length, one and a half in breadth, and one in thickness, and weighs from three to four ounces. Its duct commences at the smaller end and runs transversely through the gland: as it approaches

Fig. 38.



The Pancreas and its Relations.

the head of the gland it gradually increases in size, until it measures from one to two lines in diameter; it then curves downward and opens into the duodenum in common with the ductus communis choledochus. According to Bernard, there is a supplementary duct, which arises either from the head or other portion of the pancreas, and which opens into the duodenum about one inch above the main duct. In its structure the pancreas resembles the salivary glands, belonging, like them, to the compound racemose variety. It consists of a large number of small lobules aggregated in masses and united by connective tissue. The

lobules are rounded or elongated and give origin to small ducts which become tributary to the main duct. Each lobule is lined by a layer of cylindrical nucleated cells whose physical structure presents a marked difference between the central and peripheral ends. The central end is dark and filled with a deep layer of fine granules, while the peripheral end is clear and homogeneous. The latter is colored readily by carmine, while the former remains unstained. During the intervals of digestion the granular layer is very deep and almost entirely occupies the cell, but after the gland has been actively secreting and has discharged its secretion, the granular layer almost entirely disappears and the cell becomes clear and somewhat shrunken.

The pancreatic juice was first obtained by Bernard from a living animal in which he had established a permanent fistula. The method he adopted was as follows: A large-sized dog was selected and fed on meat five or six hours before the operation, so that the pancreas might be in active secretion. The animal was securely fastened, and an incision three inches long made in the right hypochondrium below and in the direction of the last rib. The duodenum, thus exposed, was drawn out and the pancreatic duct, which in the dog opens about an inch below the ductus communis choledochus, sought for. A delicate silver canula was then introduced into it and securely fastened by ligatures. The parts were then returned to the abdomen, and the canula left projecting through the abdominal opening, which was then carefully closed. The fluid could then at once be collected as it flowed from the canula. According to Bernard, the normal secretion can only be obtained during the first twenty-four hours; after this time the fluid becomes changed and loses its characteristic properties. Permanent fistulæ have, however, been established by Ludwig and Bernstein by the employment of a method similar to the above, but instead of using a canula they employed lead wire. One end is inserted into the duct, and the other into the intestine and secured by ligatures; the middle portion is then bent and twisted together so as to form a T-shape, which projects through the wound. After several days the ligatures are removed, but the wires remain. By suspending the animal the fluid will run down the wire and can be collected in a suitable vessel. For the purposes of experimentation a glycerin extract of the active principles of the pancreas answers every purpose, and may be prepared by cutting the pancreas, taken from an animal in full digestion, into small pieces and placing them under alcohol for several days, so as to extract all the water they contain. The alcohol is then expressed and the pulp placed under glycerin for a week or ten days. The glycerin absorbs the active principles, and can be used for experimentation.

Physical Properties and Chemical Composition of the Pancreatic Juice.—The fluid that is obtained from a temporary fistula is clear, slightly opaline, viscid, of a decidedly alkaline reaction, and has a specific gravity in the dog of 1040. When cooled to 32° F. it assumes a gelatinous consistence from the large amount of organic matter it contains. At the boiling-point it completely coagulates. The fluid obtained from a permanent fistula is more watery, and the solid constituents so far diminished in amount that coagulation will not take place. The pancreatic

juice will undergo decomposition very readily when exposed to heat and moisture, and lose its characteristic properties. Its alkalinity is increased, its coagulability is lost, and a putrefactive odor is developed. The chemical composition of this fluid, according to Schmidt, is as follows:

Composition of Pancreatic Juice.

Water	900.76
Albuminoid substances	90.44
Sodium chloride	7.35
Potassium chloride	0.02
Lime phosphate	0.41
Magnesian phosphate	0.12
Soda, lime, and magnesia in organic combination	0.90
	1000.00

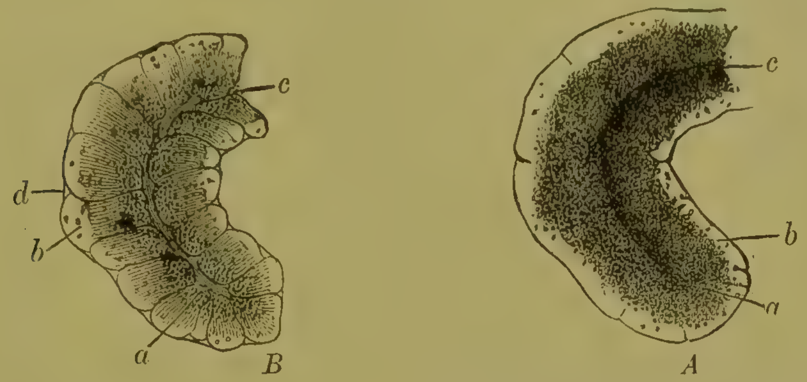
From this analysis the pancreatic juice is seen to contain 9 per cent. of solid constituents, which for the most part are organic. The organic matter is readily coagulated by heat, absolute alcohol, and the mineral acids. The precipitate by alcohol after being dried can be again dissolved, when it will become as active as it was originally. The organic matter appears to be the active constituent of this fluid, and possesses the remarkable property of breaking up fats and oils into a condition of the minutest subdivision even in a slightly alkaline medium. The organic matter has been shown to be a mixture of an albumen coagulated by boiling, an alkali-albumen precipitated by acetic acid or sulphate of magnesia, leucin, tyrosin, and three ferment bodies, upon the presence of which the different physiological actions of the secretion depend. Of the inorganic matter, the sodium carbonate is probably the most essential, as it is this salt which gives to the juice its alkaline reaction.

Mode of Secretion.—The secretion and discharge of pancreatic juice have been observed, by means of the fistula, to be not constant, but subject to very considerable variation during the twenty-four hours, the secretion being most marked after meals and ceasing almost entirely during the intervals of digestion. As soon as the food passes into the stomach, there is a sudden and remarkable increase in the flow of the juice, which lasts for two or three hours. This sudden rise in the amount discharged immediately after meals is brought about, undoubtedly, through the influence of the nervous system, though the exact mechanism is but poorly understood. Connected as it is with the introduction of food into the stomach, it is probable that impressions made upon the terminal filaments of the pneumogastric nerve ascend to the medulla oblongata, from which influences pass outward through vaso-motor nerves to the blood-vessels and secreting cells of the pancreas. After the maximum increase there is a fall in the amount poured out, to be again followed by a secondary rise coincident with the passage of the food through the pylorus into the small intestine. It then gradually diminishes in amount until the end of digestion, when it entirely ceases.

The *total amount* secreted during the twenty-four hours has been determined only approximately. Prof. Dalton states that he obtained from a dog as much as 1.25 grammes (19 grains) per hour for each

kilogramme of body-weight during digestion, but a much less quantity during the intervals. Upon this basis, and taking as the average 0.5 gramme (7.7 grains) secreted per hour for each kilogramme of body-weight, he estimated that a man of average weight secreted daily about 800 grammes, or about $1\frac{3}{4}$ pounds.

FIG. 39.



A Portion of the Pancreas of the Rabbit (Kuhne and Sheridan Lea): *A*, at rest: *B*, in a state of activity; *a*, the inner granular zone, which in *A* is larger and more closely studded with fine granules than in *B*, in which the granules are fewer and coarser; *b*, the outer transparent zone, small in *A*, larger in *B*, and in the latter marked with faint striæ; *c*, the lumen, very obvious in *B*, but indistinct in *A*; *d*, an indentation at the junction of two cells, seen in *A*, but not occurring in *B*.

During the period of glandular activity the general appearance of the pancreas differs from that when it is at rest. In the latter condition it is pale and flaccid, but becomes highly vascular and red during the process of secreting. Reference has already been made to the physical structure of the cells lining the lobules of the pancreas as consisting of two zones—an outer one, clear and homogeneous, and an inner one, broad and highly granular. The position of the nucleus of the cell varies, being at one time in the outer zone, at another time in the inner zone. If the pancreas be examined microscopically during the intervals of digestion, it will be observed that the inner zone of the cell is very broad, highly granular, and occupies nearly the entire cell, which has now become somewhat larger and swollen, while the outer zone will have become reduced to a minimum. If, however, the cells be examined while the gland is actively secreting, the reverse conditions will be observed: the inner zone will then be diminishing in width and its granular matter disappearing, while the outer zone will have approached its maximum width. This change in the condition of the cells has been verified in the living animal by Kuhne and Lea. These observers examined the pancreas of a living animal microscopically, and were enabled to see the process of secretion taking place. As soon as digestion began the granules of the broad inner zone began to pass toward the lumen of the lobule, and gradually disappeared as the secretion was poured out, while the outer zone increased in width until the entire cell became clear and homogeneous. After secretion ceased the cells again became granular. It would appear, therefore, that the blood furnished the material for the development of the outer zone, which in turn gave rise to the granular matter of the inner zone, and this finally furnished the material out of which the secretion was formed. (See Fig 39.)

The active principles of the pancreatic juice are three in number,

and belong to the ferment group of substances. They are albuminous in character, and can be extracted from the secretion by appropriate chemical means. They are—1, trypsin; 2, pancreatin; and 3, steapsin. These three ferments exert a transforming action respectively upon albuminoid, starchy, and oleaginous substances. They have not been isolated in a state of absolute purity, and their chemical composition is therefore unknown.

The ferment known as *trypsin* exerts a transforming influence upon the albuminoid principles of the food similar to the action of pepsin, converting them into peptones. This change can be brought about by operating either with the pure juice or the glycerin extract of the gland-tissue under certain conditions. If a few pieces of boiled fibrin be added to the pure juice, and be left to stand for several hours and kept at the normal temperature of the body, it will be found that the fibrin has been converted into peptones. This change is facilitated by a temperature up to 104° F. and an alkaline medium. It is arrested by boiling and an acid medium. Though the ultimate result of the pancreatic digestion of albumen is the same as the gastric digestion—viz. the production of peptones—the intermediate stages are somewhat different. In the former instance the fibrin does not swell up and become transparent, but is corroded and shrivelled, and finally dissolved. The intermediate product also is not an acid-albumen, but resembles rather an alkali-albumen. The peptones resulting from pancreatic digestion cannot be readily distinguished from those resulting from gastric digestion, and resemble them in being soluble in both acid and alkaline solutions and in being highly diffusible. If the action of the pancreatic juice be continued beyond the formation of peptones, a decomposition takes place in the albumens, with the production of two new substances, *leucin* and *tyrosin*. Inasmuch as a glycerin extract of a perfectly fresh pancreas just removed from the living animal is inert as far as the solution of the albuminoids is concerned, and the extract made from the same pancreas after twenty-four hours is highly active in this respect, it has been assumed from this and other considerations that trypsin, as such, does not exist in the gland-cells, but is formed by a decomposition of a pre-existing substance termed zymogen, this change taking place after secretion and when the juice meets with an acid in the alimentary canal.

The second ferment, *pancreatin* or *amylopsin*, is identical in its action with the ferment of the saliva. It possesses the power in a marked degree of transforming starch, either raw or hydrated, into glucose at the normal temperature of the body. It is indeed the most energetic amylolytic ferment known to physiological chemists. Both the pure juice, the infusion of the gland, and the glycerin extract are equally capable of exerting this change. This ferment can be readily extracted from the pancreas by digesting small pieces of the gland in lime-water, and subsequently adding phosphoric acid until a copious precipitate of phosphate of lime is produced. This method is employed for the reason that the precipitate carries down with it the ferment and other organic matter; but as the latter adheres more tenaciously to the calcium precipitate than the former, the ferment can be easily washed away and

precipitated by alcohol in excess. It can then be dried, and if kept under glycerin or alcohol will retain its amylolytic properties for an indefinite time.

The third ferment, termed *steapsin*, has never been satisfactorily isolated. This substance possesses the remarkable property of acidifying the neutral fats, decomposing them into fatty acids and glycerin. If either the pure juice or an infusion of the gland-tissue be added to a neutral fat and kept at the temperature of the body for a few hours, the fluid will acquire a markedly acid reaction, and if continued for twenty-four or thirty-six hours the acidification will have become complete. The chemical reaction that takes place when a neutral fat is split up into a fatty acid and glycerin is represented. according to Dr. Laurence Wolff, in the following formula—viz.:

$$\underset{\text{Triolein.}}{C_3H_5(C_{18}H_{33}O_2)_3} + \underset{\text{Water.}}{3H_2O} = \underset{\text{Oleic acid.}}{(C_{18}H_{34}O_2)_3} + \underset{\text{Glycerin.}}{C_3H_8O_3}.$$

If the decomposition takes place in the presence of an alkali, the acid thus liberated unites with it and is saponified—*e. g.*:

$$\underset{\text{Oleic acid.}}{C_{18}H_{34}O_2} + \underset{\text{Potassium hydrate.}}{KHO} = \underset{\text{Potassium oleate.}}{KC_{18}H_{33}O_2} + \underset{\text{Water.}}{H_2O}.$$

Physiological Action of the Pancreatic Juice upon Albumen.—The action of the pancreatic juice upon the albuminoid articles of food has already been alluded to when discussing the properties of the ferment trypsin. Although this secretion possesses this remarkable property in common with gastric juice, it must be regarded, however, as a secondary process. Although the main disintegration and solution of the food are brought about by the action of the hydrochloric acid and pepsin in the stomach, nevertheless a certain portion passes into the intestine but slightly changed; for if the contents of the intestine be examined microscopically after the digestion of an ordinary meal of meat and vegetables, there can be distinguished muscular fibres in various stages of disintegration: they are broken into small pieces, are pale in color, and their characteristic striations have nearly disappeared. The same condition of imperfect digestion is observed in the vegetable tissues and fat-vesicles. If the digesting mass, however, be examined in successive portions of the small intestine, a still further disintegration and liquefaction will be observed to have taken place, until finally there remain only a soft, pultaceous mass and a residue of hard, indigestible matter.

Even though the intestinal juice is capable of transforming albuminoids into peptones, it is highly probable that the pancreatic juice is the main agent in digesting the albuminoids in the intestine. The importance of the pancreatic juice in this respect was shown by the experiments of Bernard. After the partial destruction of the pancreas in dogs, and a consequent interference with the secretion of the juice, there soon resulted a marked decline in the health of the animal. Though the appetite became voracious, emaciation soon set in, followed by a progressive failure of the general nutrition. The feces of the animal were found to contain albuminous matters unchanged, in addition to starch and fats. The results of these experiments demonstrated that the pancreatic juice

was an important agent in the digestion of the albuminoid articles of the food.

Upon Starch.—Although the saliva and intestinal juice are effective agents in the transformation of starch into sugar, this process is materially assisted by the pancreatic juice. Indeed, it is regarded by many observers as the most energetic in this respect of all the secretions, effecting the conversion almost instantly. As soon as the starch passes into the intestine from the stomach and comes into contact with the pancreatic secretion, glucose at once makes its appearance. *Cane-sugar*, which constitutes a large percentage of all the saccharine matter taken as food, is also transformed into glucose by the pancreatic juice. This important observation was originally made upon the inferior animals, but has been verified and found to hold true of the human pancreatic juice by Busch in the case of intestinal fistula already referred to. This observer found that when cane-sugar was introduced into the lower opening of the intestine, it could readily be shown to be present in the dejections unchanged, the intestinal juice, with which alone it came in contact, not possessing this transforming property; but when the cane-sugar was taken into the stomach, it passed out of the superior opening completely transformed into glucose, having been acted upon in this portion of the intestine by the pancreatic juice. It is therefore evident that this digestive fluid is also highly important in the digestion of the starchy and saccharine articles of the food.

Upon Fats.—The action of the pancreatic juice upon the fats is its most prominent characteristic and constitutes one of the most important stages of digestion. This action consists in the reduction of the fats to a state of the minutest subdivision and suspension, forming an emulsion which is complete and permanent. This change is instantly brought about when the fat and pancreatic juice are mingled together at the normal temperature of the body. This property is not possessed by any of the other digestive fluids. It was at one time supposed that the intestinal juice was also capable of emulsifying the fats; but in the case of the intestinal fistula under the care of Busch it was demonstrated that it did not possess this property. Whenever the fats were introduced into the lower opening of the bowel, they were discharged from the rectum unchanged.

If the pancreatic juice be placed in a test-tube with olive oil, in the proportion of two parts of the former to one of the latter, and then agitated for a few moments, there is produced a thick, creamy fluid which, when examined under the microscope, is seen to be composed of exceedingly small globules of fat. This emulsification of the fats, which had long been known, was originally attributed to the influence of the bile, but it was reserved for Bernard to demonstrate that it was due to the pancreatic secretion. This observer showed that in the rabbit the pancreatic duct does not enter the intestine at the same point the bile-duct does, but some eighteen or twenty inches below it, and that when this animal was fed upon fat it did not suffer any change, notwithstanding its admixture with the bile, until it had passed the orifice of the pancreatic duct, when at once a white, creamy emulsion was formed similar to that formed in the test-tube.

That the pancreatic juice is the active emulsifying agent of the fats and oils has been abundantly shown both by pathology and experiment. Numerous cases of fatty diarrhœa are to be found in the records of clinical medicine, which, as shown by post-mortem examination, were attended with a destruction of the pancreatic tissue. Bernard also destroyed the pancreas in several instances by injecting into its duct melted tallow. The secretion was at once stopped, with the result of disturbing the process of digestion, and ultimately the general nutrition of the animal. As there was an absence of the emulsifying agents, the fats that were consumed by the animal were found in the feces in an undigested and rancid condition. Whenever the pancreas has been disorganized, either by disease or by an experiment, the fatty articles of the food have always appeared in the dejections unchanged.

The decomposition of the neutral fats into their respective fatty acids and glycerin when subjected to the action of the pancreatic juice is not nearly so marked in the intestinal canal as it is outside of the body. Though the development of these acids and their subsequent saponification may take place to a slight extent during digestion, the lacteal vessels take up but a small percentage only of these substances, the contents of the lacteal vessels being composed almost entirely of undecomposed fat. Summing up, it may be stated that the physiological action of the pancreatic juice is—1, to convert the albuminoid articles of the food into peptones; 2, to transform starch and cane-sugar into glucose; 3, to emulsify the fats.

THE BILE.—The liver is the largest organ in the body, and performs the double office of—1, secreting bile, and 2, of secreting glycogen. Of these two functions, the first is the more important in its relation to the process of digestion, and will alone be considered in this connection. The liver is a highly vascular, conglomerate gland, weighing about four and a half pounds. It is situated in the right hypochondriac region, and is retained in position by five ligaments, four of which are formed by folds of the peritoneal membrane, while the fifth is the remnant of the fœtal umbilical vein. The fibrous coat of the liver surrounds the entire organ, and is closely connected with the areolar or connective tissue which penetrates the substance of the liver. The liver is made up of a large number of small bodies, polyhedral in shape and measuring about the $\frac{1}{25}$th of an inch in diameter. These are the liver-lobules. They are closely packed together, but separated by a slight space, in which are situated the blood-vessels, hepatic ducts, nerves, and lymphatics, supported by connective tissue. In some animals, as the pig, they are distinctly visible to the naked eye.

Hepatic Cells.—When examined microscopically the main portion of the lobules is seen to be composed of cells. These cells are compressed, polyhedral in shape, and measure on the average the $\frac{1}{1000}$th of an inch in diameter. They are yellowish in color, and contain one, and at times two, nuclei. They also contain transparent globules of fatty pigment matter and animal starch. The cells constitute the true secreting structure of the liver, and are in direct contact with capillary blood-vessels.

Blood-vessels.—The liver is highly vascular, and different from all

other organs in receiving its blood-supply from two sources—viz. (1) the portal vein, made up by the union of the gastric, splenic, superior and inferior mesenteric veins; and (2) the hepatic artery, a branch of the cœliac axis. The distribution of the blood-vessels within the liver substance is characteristic, and closely connected with its physiological action. The portal vein enters the liver at the transverse fissure, and in its course subdivides into smaller and smaller branches, which finally ramify between the lobules, limiting and surrounding them, constituting the plexus of *interlobular veins.* From this plexus numerous small branches penetrate the substance of the lobule and terminate in a fine capillary network. The hepatic artery pursues the same course as the portal vein, and gives off branches which supply the various structures of the liver with nutritious material. Its interlobular branches are of small diameter, and transmit their blood directly to the fine capillary plexus in the substance of the lobules. The capillary network is exceedingly fine, and in its meshes are found the true hepatic cells. The blood, after being distributed through this plexus, is directed by small veins running toward the centre of the lobule, where they terminate in a single efferent vessel, the *interlobular* vein. This vein passes directly through the lobule and empties into the *sublobular* veins, which finally unite to form the hepatic veins, which terminate in the vena cava.

The *bile-ducts* or *channels* originate in the substance of the lobules in a fine plexus which surrounds the liver-cells. These channels are destitute in their beginning of either a distinct membranous wall or an epithelial lining. They receive the bile secreted by the liver-cells and empty into the interlobular bile-ducts. These vessels, ramifying between the lobules, are composed of a distinct membranous wall lined by flattened epithelial cells. They measure about the $\frac{1}{2000}$th of an inch in diameter, but as they gradually unite they form larger and larger vessels, the walls of which are strengthened by fibrous tissue: finally, these largest ducts unite to form the main hepatic duct. Situated in the walls of the bile-ducts throughout their extent in the liver are immense numbers of small glands, racemose in character, formed of a basement membrane and lined by cells. They probably secrete mucus. The hepatic duct emerges from the liver at the transverse fissure. It is formed by the union of two branches which come from the right and left lobes of the liver. It is about two inches in length, two lines in diameter, and joins with the cystic duct to form the common bile-duct. The common duct, the ductus communis choledochus, is three inches in length, three lines in diameter, and opens into the duodenum by a common orifice with the pancreatic duct, situated about three inches below the pyloric opening. The cystic duct is about an inch in length. The walls of the ducts are composed of an internal mucous coat covered by columnar epithelial cells, and of an external fibrous and muscular coat.

The gall-bladder is a receptacle for the bile. It is an ovoid or pear-shaped sac about four inches in length, situated in a fossa on the under surface of the liver. It is capable of holding from an ounce to two ounces of fluid. Its walls are composed of an external coat of fibrous tissue with elastic and muscular fibres, and of an internal coat of

mucous membrane. The neck of the gall-bladder gradually narrows into the cystic duct.

Physical Properties and Chemical Composition of Bile.—The bile obtained directly from the liver through a fistulous opening in the hepatic duct is always thin and watery, while that obtained from the gall-bladder is more or less viscid and ropy from admixture of mucus, the degree of this viscidity depending upon the length of time it remains in this reservoir. The specific gravity of human bile varies within normal limits from 1020 to 1030. The reaction is invariably alkaline in the human subject when first discharged from the liver, but may become neutral in the gall-bladder when mixed with mucus. Like the pancreatic secretion, the bile readily undergoes putrefactive changes and becomes offensive, though when perfectly fresh it is inodorous. When shaken with water it becomes frothy—a condition which lasts for some time and is dependent upon the presence of certain organic salts. The color of the bile obtained from the hepatic ducts is variable, usually a shade between a yellowish-green and a brownish-red. In different animals the color varies. In the herbivorous animals it is quite green; in the carnivorous animals it is orange or brown. The red and green colors of the bile are due to the presence of the coloring matters, bilirubin and biliverdin. These two principles are formed in the liver by the liver-cells, and discharged into the bile-ducts. In all probability they are derived from the coloring matter of the blood, hæmoglobin. Their presence in a suspected solution can be determined by means of Gmelin's test, which consists in adding a small quantity of nitroso-nitric acid to a thin layer of the fluid upon a white surface. If the coloring principles be present, a series of colors will succeed one another, commencing with a green and passing to a blue, orange, purple, to yellow. This play of colors is caused by an oxidation of the coloring matter by the acid. Microscopical examination does not show the presence of structural elements, nor are there traces of albuminoid substances.

The chemical composition of human bile obtained from an accidental biliary fistula was shown by Jacobson to consist of the following ingredients—viz.:

Composition of Human Bile.

Water	977.40
Sodium glycocholate	9.94
Cholesterin	0.54
Free fat	0.10
Sodium palmitate and stearate	1.36
Lecithin	0.04
Other organic matters	2.26
Sodium chloride	5.45
Potassium chloride	0.28
Sodium phosphate	1.33
Lime phosphate	0.37
Sodium carbonate	0.93
	1000.00

In this analysis the solid ingredients constitute 22.5 parts per 1000, of which two-thirds are organic and one-third is inorganic. The amount of solid matter varies, however, according to the animal from which it

is obtained. Of the various ingredients of the bile, none are more interesting and important than the sodium glycocholate and taurocholate. These principles, sometimes known as the biliary salts, were originally obtained from ox bile by Strecker. The taurocholate of soda is usually found in the bile of the carnivorous animals, the glycocholate in the bile of the herbivorous animals. In the above analysis the glycocholate was present, though taurocholate could occasionally be found as a mere trace. The glycocholate of soda is a compound of glycocholic acid and soda, the former of which can be decomposed into a nitrogenized body, glycin and cholalic acid. It is a crystalline substance, soluble in water and alcohol, but insoluble in ether. According to Prof. Dalton, who has carefully studied the bile, this salt can be obtained by the following method: The bile is first evaporated to dryness. The dry residue, after being pulverized, is extracted with absolute alcohol. When filtered and decolorized with animal charcoal, the alcohol solution is clear and yellowish in color. By the addition to this fluid of eight or ten times its volume of ether a whitish precipitate takes place, which collects in drops resembling oil-globules. In the course of twenty-four hours the sodium glycocholate begins to crystallize in fine needle-shaped crystals.

The sodium taurocholate is sometimes found in the human bile in greater proportion than the glycocholate. This salt consists also of soda in combination with taurocholic acid, the latter being separable into a nitrogenized substance, taurine and cholalic acid. It is soluble in water and alcohol, insoluble in ether. It can be obtained from the bile by following a method in most respects similar to the above. It also crystallizes in the form of slender acicular needles. These two salts originating in the liver are products of secretion, and in all probability are derived from albuminous compounds. They are in no sense waste products, for their presence has not been satisfactorily demonstrated in the blood, urine, or feces, except as a mere trace in the latter. About 230 grains of these salts are secreted daily. After being discharged into the intestine along with the other constituents of the bile, they undergo certain changes and can no longer be recognized by the ordinary tests. They are probably reabsorbed into the blood to play some ulterior part in the nutrition of the body. The digestive properties of the bile have been attributed to the presence of these substances.

The test usually employed for the detection of the biliary salts is that proposed by Pettenkofer. If it be carefully conducted and certain well-known sources of error eliminated, it is perfectly trustworthy. Should organic matter be present in the suspected liquid, it will be necessary to evaporate it to dryness and extract the dry residue with absolute alcohol. This solution, if necessary, is then decolorized with animal charcoal and precipitated with ether in excess. If the precipitate be then dissolved in water, a clear solution will be obtained. To this fluid a drop or two of a solution of cane-sugar in water, one part to four, are added for each cubic centimeter of the suspected liquid. Sulphuric acid is then slowly added, so that the temperature may not rise above 150° F. If the bile-salts be present, a deep-red color, which changes to violet or purple, then makes its appearance. If the amount of the salts be

large, the change in color is immediate, but if they are present only in small quantity, the change may not take place for some time.

Cholesterin is a constant constituent of the bile, though it is not confined to this fluid, its presence having been determined in the liver, crystalline lens, blood, nervous system, and in various pathological fluids. It is an organic non-nitrogenized substance, resembling the fats in some particulars, but differing from them in not being capable of saponification with the alkalies. When examined microscopically it is seen to be composed of crystals which are thin, transparent, and rectangular in shape. They frequently occur in piles, and partly overlap one another, and, as they are transparent, the outlines of those lying beneath are clearly visible. These crystals are insoluble in water, but exceedingly soluble in ether and boiling alcohol. When mixed with sulphuric acid they assume a red color which gradually changes to violet. Cholesterin is regarded as a product of waste of nervous tissue, from which it is absorbed by the blood and finally eliminated by the liver. Its presence in the feces has not been shown, except as a mere trace, being changed, according to Prof. Flint, into stercorine, and as such discharged from the body.

The manner in which the bile flows from the liver into the main hepatic ducts, the variation in the rate of its discharge, and the total quantity secreted daily have been approximately determined by means of a fistulous opening either in the hepatic duct or in the gall-bladder. As the bile, as such, has never been demonstrated to exist in the blood of either the hepatic artery or the portal vein, its origin is to be looked for in the liver substance itself. Although the liver presents some physiological peculiarities, there is no reason to believe that the conditions of secretion therein are different from those in any other organ, or that any other structure than the cell is engaged in this process. The liver-cells, from their close relationship to the capillary blood-vessels, are undoubtedly the essential agents concerned in the production of the bile. As shown by the chemical composition, the bile consists of principles some of which, as the biliary salts, are formed in the liver *de novo*, by an act of true secretion from materials derived from the blood, while others, as cholesterin and lecithin, are principles of waste which are simply extracted from the blood to be eliminated from the body. The bile is thus a double fluid consisting of both secretory and excretory principles.

The particular blood-supply from which the liver obtains material for the elaboration of the bile, whether from the portal vein or from the hepatic artery, was at one time a matter of much discussion. But the result of numerous experiments made with a view of determining this point shows that the blood of either vessel is capable of furnishing materials out of which the biliary constituents can be formed. In many instances the hepatic artery has been ligated with the result of entirely cutting off the arterial supply, without, however, interfering with the secretion of the bile. On the other hand, several instances of successful obliteration of the portal vein by slow compression, completely diverting the blood into other channels, have been reported, and yet the bile continued to be secreted as formerly. It appears certain,

therefore, that the bile is elaborated by the liver-cells from materials furnished by both arterial and venous blood.

The flow of the bile from the liver substance into the main hepatic duct has by means of a fistula of the gall-bladder been shown to be continuous, but subject to considerable variation during the twenty-four hours. Among the influences which affect the rate of discharge none are more direct than the process of digestion. The introduction of food into the stomach at once causes a slight increase in the flow, but it is not until about two hours after, that the amount secreted rapidly increases, and continues up to the eighth hour, when it reaches its maximum, after which it gradually decreases, but never entirely ceases. During the intervals of digestion, though a small quantity of bile passes into the intestine, the main portion is diverted into the gall-bladder, which acts as a reservoir, and is there retained until intestinal digestion takes place. In animals which have been deprived of food for a length of time the gall-bladder becomes so distended with bile that it can be often felt at the lower margin of the last ribs. When, however, the acidulated food begins to pass from the stomach into the small intestine and over the orifice of the bile-duct, at once there takes place, through reflex action, a contraction of the muscular walls of the gall-bladder and a sudden gush of bile, the discharge of the bile into the intestine continuing at a rapid rate until digestion ceases and the intestine is emptied of its contents.

The total quantity of bile secreted and discharged from the liver in twenty-four hours has been, as in the case of the other secretions, only approximately determined. Different observers have attempted to estimate the quantity secreted by the human liver by experimenting upon the lower animals and then applying their results to man. The experiments of Bidder and Schmidt are probably the most reliable, and were conducted in the following manner: The common choledoch duct was first ligated, so as to prevent the escape of any bile into the intestine; a fistula was next made in the fundus of the gall-bladder, through which the bile could be collected and weighed. In this way these observers obtained from a dog in an hour 0.832 grammes for every kilogramme of body-weight, and they estimated from this that 19.9 grammes (306 grains) were secreted daily for every kilogramme of body-weight. Applying this result to a man weighing 60 kilogrammes, the amount secreted by his liver daily would be $19.9 \times 60 = 1194$ grammes, or $2\frac{1}{2}$ pounds.

Physiological Action of the Bile.—The fact of so large a quantity of fluid being poured into the intestine daily, and especially during the period of the greatest activity of the digestive process, would lead to the inference that the bile exerted some important influence in the preparation of the different alimentary principles for their absorption into the blood. But, notwithstanding the investigations of many physiologists, no definite or specific action has been attributed to it. The evidence in reference to its power of transforming any of the constituents of the food into the forms under which they are absorbed has been rather of a negative character than otherwise. Upon the *albuminoid* substances no change of any kind has been shown to take place when subjected to the

action of bile. The same can be said in reference to its action upon *starch*. Some observers, however, have assigned to it the power of converting starch into glucose, but this effect is so feeble and inconstant that it is questionable if it can be regarded as a property of the bile. Upon the *fats* and *oils* the bile has only a slight and imperfect emulsifying action, nothing comparable, however, to that of the pancreatic secretion. When oil and bile are shaken together the emulsion that is produced is very imperfect, and the two fluids after a short interval again separate. With fatty acids, however, the bile forms soaps, and in this way may assist the pancreatic juice in forming a more complete emulsion.

As an aid to intestinal digestion the bile has been regarded by many observers as highly important by neutralizing the products of gastric digestion when they pass into the duodenum. When the partially-digested food passes over the orifice of the bile-duct and becomes incorporated with the alkaline bile, a neutralization of the hydrochloric acid takes place, after which the pepsin becomes inactive. A precipitation of the acid-albumen, syntonin, is also produced by the biliary salts. In this way the action of the gastric juice is arrested and the food prepared for further solution by the pancreatic and intestinal secretions, both of which, it will be remembered, are alkaline in reaction.

The bile, in virtue of its property of wetting animal membranes, also promotes the absorption of fatty matters by the epithelial cells covering the villi. This property is possibly due to the presence of the biliary salts. If a piece of animal membrane or filtering-paper be first moistened with water, and then covered with emulsified fat, little if any will pass through it, but if it be wetted first with bile, the small particles of fat will adhere to the surface of the membrane and readily pass through it. That the bile influences the absorption of the fat in some way at least is shown by the fact that when the bile is prevented from entering the intestine, either from ligation of the common choledoch duct or from disease of the biliary passages, there is found in the feces an abnormal quantity of fatty matter, and at the same time there is observed in the chyle a diminution in the proportion of the fat usually present under normal conditions.

The bile also acts as a stimulant to the muscular walls of the intestine, exciting the peristaltic action by which the food is propelled from above downward and its absorption promoted and facilitated. In the absence of the bile the muscular contraction is not nearly so active, and in consequence the bowels become torpid and sluggish and the fecal matters accumulate in the intestine. By some observers it is thought to have an important influence as an antiseptic during digestion by preventing putrefactive changes in the food and the development of offensive gases.

Though no definite or specific action upon any of the different classes of alimentary principles can be attributed to the bile, there is abundant evidence that its presence in the alimentary canal during digestion is highly essential to the maintenance of the nutrition of the body. As before stated, it is very probable that as the bile passes down the intestine a portion of it at least (the biliary salts) is reabsorbed into the

blood. That the bile as a whole, or at least part of its constituents, favorably influences digestion and the nutrition of the body is shown when it is prevented from entering the intestine by the ligation of the common choledoch duct and the establishment of a fistula in the fundus of the gall-bladder. This operation has been successfully performed a number of times by Schwann, Bidder and Schmidt, Bernard, and Flint, and the latter records in his work on physiology the details of a very successful experiment in which he was able to verify the observations of other observers. It is a typical instance of the series of changes that follow the diverting of the bile from the intestine. The following abbreviated account of this experiment is taken from his work: The animal employed by Flint was a young cur weighing twelve pounds. An incision three inches in length was made through the abdominal walls in the median line just below the ensiform cartilage. The common bile-duct was ligated and an opening made in the fundus of the gall-bladder, the edges of which were fastened to the abdominal walls. The opening in the gall-bladder was kept patulous by the introduction occasionally of a glass rod. During the first five days succeeding the operation the abdomen was tumid and there was some rumbling in the bowels. Though the animal ate every day, the discharge of fecal matter became infrequent, the matter passed being grayish in color and highly offensive. After two weeks the alvine discharges took place three and four times daily. For four days the weight remained normal; afterward it began to diminish, and from this time the animal continued to lose strength and weight until his death, thirty-eight days after the operation, when he weighed seven and a half pounds. Ten days after the operation his appetite, which had been very good, now increased, but did not become ravenous until a few days before his death. The animal usually ate from a pound to a pound and a half of beef-heart daily. He never would eat any fat. There was an absence at all times of jaundice, fetor of the breath, or falling of the hair. Post-mortem examination showed that the bile-duct was obliterated, and there was no evidence that any bile could have passed into the intestine. The results of this and similar cases go to show that that portion of the bile which is secretory in character is essential to digestion and the nutrition of the body—that, though large quantities of food are consumed, progressive diminution of weight takes place until nearly 40 per cent. of the body is consumed. In some instances the breath became fetid and there was a falling of the hair, showing some profound disturbance of the nutritive process.

Normally, there is present in the small intestine varying proportions of different gases, notably carbonic acid gas, hydrogen, and nitrogen, which in a purely mechanical manner influence favorably digestion and absorption. By keeping the bowels distended the food can pass along unhindered, the capillary circulation is uninterfered with, and concussion of abdominal viscera prevented. They probably originate in the decomposition of different articles of food.

During digestion the food is propelled from above downward by a wave-like contraction of the muscular coat of the intestine. This movement, known as the peristaltic movement, is exceedingly slow and

worm-like, creeping along the intestine in a progressive manner and carrying the food throughout its entire length. These movements are well observed when the abdomen of an animal recently killed is opened and the intestine exposed to the air. It is probable, however, that under these circumstances they are somewhat more vigorous than in the living condition. The peristaltic action is produced by the contraction of both the circular and longitudinal fibres. By the contraction of the former the calibre of the intestinal canal is constricted behind a portion of food, and as the constriction advances the food is carried forward by it. At the same time, the longitudinal fibres contracting, the canal is shortened in its long diameter and drawn up over the advancing portion of food. These movements of the intestines are undoubtedly reflex in character, the exciting cause being the presence of food in the intestinal canal.

As a result of the action of the saliva, the gastric juice, the pancreatic and intestinal juices, and the bile, the food is gradually changed in its physical properties, undergoing disintegration and liquefaction. The alimentary principles, albumen, starch, cane-sugar, and fat, freed from their combinations, are changed in their chemical composition and transformed into *albuminose*, *glucose*, and *fatty emulsion*, under which forms they are absorbed by the veins and lacteals into the blood. When the nutritious matter has been absorbed the residue of the food, comprising the innutritious and indigestible matter, passes out of the small intestine into the large intestine, and forms a portion of its contents.

Large Intestine.—The large intestine—so called because it exceeds in diameter by about one and a half inches the preceding portion of the alimentary canal—extends from the termination of the ileum to the anus, and measures from five to six feet in length. Its diameter varies from two and a half inches at its origin to about one and a half inches at the junction of the sigmoid flexure and the rectum; beyond this point the intestine again dilates into a pouch before it terminates at the anus. The large intestine is divided into the cæcum, the colon (subdivided into an ascending, transverse, and descending portion, including the sigmoid flexure), and the rectum.

The cæcum, or caput cæcum coli, is situated in the right iliac fossa. It is that dilated portion of the large intestine situated below the orifice through which the small intestine empties its contents. It measures about two and a half inches in breadth and the same in length. In the posterior and inner wall of the cæcum is a small round opening about the size of a goose-quill which leads into a narrow round process, the appendix vermiformis. This appendix measures from two to five inches in length, is coiled upon itself two or three times, and finally terminates in a blind extremity. The opening of the small intestine into the cæcum is somewhat narrow and elongated, and is guarded by two folds of mucous membrane strengthened by fibrous and muscular tissue. These folds constitute the so-called ileo-cæcal valve, and when the cæcum is distended their margins are approximated, and effectually prevent the return of material into the small intestine.

The ascending colon extends from the right iliac fossa upward through the right lumbar and hypochondriac regions to the under surface of the liver, where it bends to the left at nearly a right angle and

is continued as the transverse colon. This latter portion of the colon runs across the upper umbilical region to the left hypochondriac region, at which point it bends downward and becomes the descending colon. This portion passes through the left hypochondriac and lumbar regions into the left iliac fossa, where it bends upon itself and forms the sigmoid flexure.

The rectum is a dilated pouch situated within the true pelvis. It measures from six to eight inches in length. Within an inch of its termination at the anus it presents a constriction formed by the internal sphincter muscle.

Structure of the Large Intestine.—The walls of the large intestine, like those of the rest of the alimentary canal, consist of three distinct coats—viz. the serous, muscular, and mucous.

The serous coat is simply a reflection of the general peritoneal membrane which covers most of the abdominal viscera, and needs no further description.

The muscular coat consists of both longitudinal and circular fibres. The former are not distributed all around the intestine, but are collected into three flat bands half an inch in breadth, and situated, one on the anterior, the other two on the lateral, aspect of the intestine. Commencing at the cæcum, these muscular bands ascend along the colon and follow it as far as the rectum, where they spread out and form a thin layer which completely surrounds this organ. As the longitudinal fibres are somewhat shorter than the intestine itself, its surface becomes somewhat irregular, presenting throughout its curve distinct sacculi, partly separated from each other by intervening constrictions. The circular muscular fibres are quite pale in color and not very numerous. They are arranged in the form of a thin layer over the entire large intestine. Between the sacculi, however, they are more numerous, and in the rectum, about an inch above the anus, they are thickly grouped together so as to form a well-developed muscular band, sometimes known as the internal sphincter.

The mucous membrane of the large intestine is thicker and firmer than that of the small intestine, and differs from it still further in not possessing villous processes or valvulæ conniventes. When freed from mucus and examined with a lens of even low power, its surface presents an immense number of small orifices which lead into closed tubules arranged vertically to the surface. These tubules resemble those of the stomach and small intestine, being composed of basement membrane and lined by columnar epithelial cells. The fluid poured out by these glands is thick and glairy. Its chemical composition is unknown, and no digestive properties have been attributed to it. It probably acts only mechanically, serving to lubricate the inner surface of this portion of the intestine.

Contents of the Large Intestine.—As was previously stated, the nutritious portions of the food are absorbed into the blood while the intestinal contents are being propelled from above downward under the influence of the peristaltic movements of the muscular walls. By the time the contents of the intestine reach the termination of the ileum the nutritious matters have been so completely absorbed that nothing

remains but the hard, indigestible matters that resisted the solvent action of the intestinal fluids. When carefully examined this residue is seen to consist of the hard parts of the cereals, cellulose, vegetable seeds, etc., the quantity and quality of these substances depending largely upon the character of the food ingested. These substances, passing into the large intestine along with the excrementitious matter of the bile, become incorporated with the mucous secretion and constitute the feces, which under the influence of the peristaltic movement are carried downward to the sigmoid flexure, where they accumulate prior to their expulsion from the body. The total quantity of fecal matter discharged daily varies from two to ten ounces, but the average amount is about four ounces. The consistence of the fecal matter varies from fluid to semisolid, depending largely upon the length of time it remains in the intestine and the extent to which absorption of its watery portion takes place. The odor is characteristic, and due to the presence of a crystalline body, indol, resulting from the putrefaction of albuminoid bodies induced by the presence of bacteria. Chemical analysis of the feces has shown that they consist largely of water, excretin, stercorin (both of which are crystalline bodies), and inorganic salts. Stercorin, as has been shown by Prof. Flint, is an important excrementitious principle resulting from the transformation of cholesterin.

Defecation is the final act of the digestive process, and consists in the expulsion of the innutritious residue of the food from the intestine. This act usually takes place in man but once in twenty-four hours, as the diet consumed daily contains but a minimum amount of indigestible material. In all of the herbivorous animals, which ingest large quantities of food containing but a minimum amount of nutritious matter, the quantity of fecal matter discharged is proportionately large. Previous to their expulsion from the body the feces which have accumulated in the sigmoid flexure pass through its constricted portion into the rectum, and in so doing develop the sensation which leads to defecation. The descent of the feces is accomplished by the peristaltic contraction of the muscular walls of the intestine. Usually, the sphincter muscle which guards the anal orifice is firmly contracted and prevents the escape of gaseous or semisolid matters. The sphincter muscle is of the striated variety, and contracts with very considerable power. It is under the influence of a nerve-centre situated in the lumbar region of the spinal cord. This centre is inhibited or increased in its action by a voluntary effort or by stimuli coming from the periphery. In the effort at defecation the rectal centre is inhibited in its action both by a stimulus coming from the rectum and by a voluntary impulse descending the spinal cord. As a result, the sphincter is relaxed, and under the contraction of the muscular walls of the rectum the feces are expelled. At the same time the levator ani muscle, contracting, dilates the anal orifice, while the abdominal muscles and diaphragm, contracting, press upon the large intestine and assist the action of the intestinal and rectal walls.

PHYSIOLOGY OF VOICE AND SPEECH.

By CARL SEILER, M. D.

The Voice.

The voice is produced in the animal body by the combined action of a number of different organs which by their individual efforts contribute to the production of an audible sound. These organs are—first, the larynx, which contains the vocal cords; then the lungs, with the trachea; and finally, the cavities of the pharynx, mouth, and nose. Taking them up seriatim, we will quickly review the anatomical details essential to voice-production for the sake of refreshing the reader's memory, and then inquire more in detail into the method by which an audible sound is produced.

Fig. 40.

Hyoid Bone and the Laryngeal Cartilages (Ellis): G, body of the hyoid bone; H, large cornu; J, small cornu; A, epiglottis; B, thyroid cartilage; C, arytenoid cartilage; D, cricoid cartilage; E, upper cornu, and F, lower cornu of the thyroid cartilage.

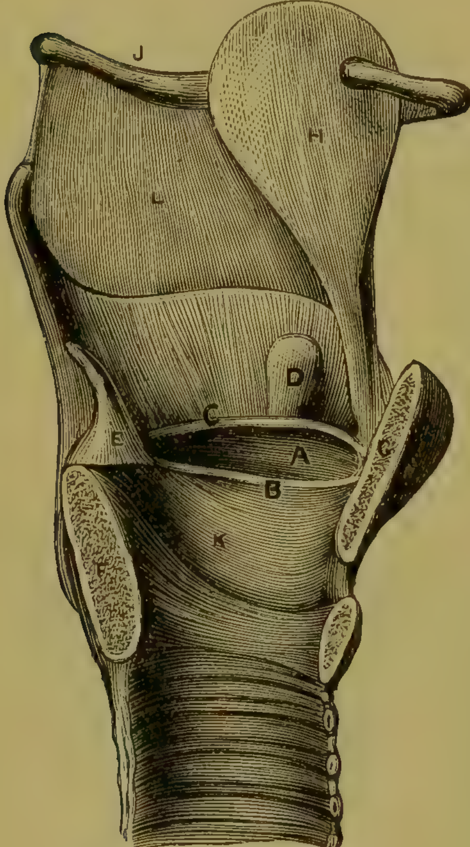
Anatomy of the Larynx.—The larynx is the funnel-shaped expansion of the trachea situated at the upper part of the air-passages. Its lower, narrow portion is circular, while its upper expansion presents a triangular appearance. It consists mainly of nine cartilages—three single and three in pairs—which are held together by ligaments and are moved upon each other by numerous small muscles. The interior of this cartilaginous tube is lined with mucous membrane, which is thrown into two pairs of folds, and is covered with ciliated epithelium, except at the lower folds, the vocal cords, which are covered with tessellated epithelium (Fig. 40).

The largest of these cartilages is the thyroid cartilage, which is composed of two lateral rings joined in front at an acute angle, thus forming the so-called "Adam's apple," and giving the whole cartilage the shape of a snow-plough. This is mounted by means of projections from the lower posterior border, called the lesser horns, upon the cricoid cartilage, in such

a fashion that the former can rock backward and forward upon the latter cartilage.

The cricoid cartilage is ring-shaped, and presents a large plate posteriorly, the upper margin of which is notched in the middle, thus presenting two rounded elevations. Upon these elevations are mounted the two arytenoid cartilages, small pyramidal bodies of cartilage, in such a manner that they can slide from side to side and at the same time can be rotated in any position. These arytenoid cartilages present at their base, and pointing into the interior of the larynx, a projection called the vocal process. Opposite to the notch in the upper margin of the cricoid cartilage is a large spoon-shaped cartilage, the epiglottis, inserted in the angle formed by the junction of the two lateral wings of the thyroid cartilage. This is connected with the arytenoid cartilages by means of two folds of mucous membrane called the aryteno-epiglottidean folds, which contain each two small cartilaginous nodules, the cartilages of Santarini and of Wrisberg.

FIG. 41.



Vocal Apparatus, on a Vertical Section of the Larynx (Ellis): A, ventricle of the larynx; B, vocal cord; C, ventricular band; D, sacculus laryngis; E, arytenoid cartilage; F, cricoid cartilage; G, thyroid cartilage; H, epiglottis; K, crico-thyroid ligament; L, thyro-hyoid ligament.

The lateral wings of the thyroid cartilage have on their anterior upper margin two long processes called the greater horns, which are united by means of short ligaments to the greater horns of the hyoid bone, so that in this manner the larynx is suspended, so to speak, in the throat, while the lower margin of the cricoid is mounted upon the uppermost ring of the trachea.

The most important anatomical details from our point of view are two prismatic bands or folds running from the vocal processes of the arytenoid cartilages forward to the angle of the thyroid cartilage, where they are joined and are fastened a little below the insertion of the epiglottis, thus dividing the interior of the laryngeal cavity into two compartments, an upper and a lower one. (See Fig. 41.)

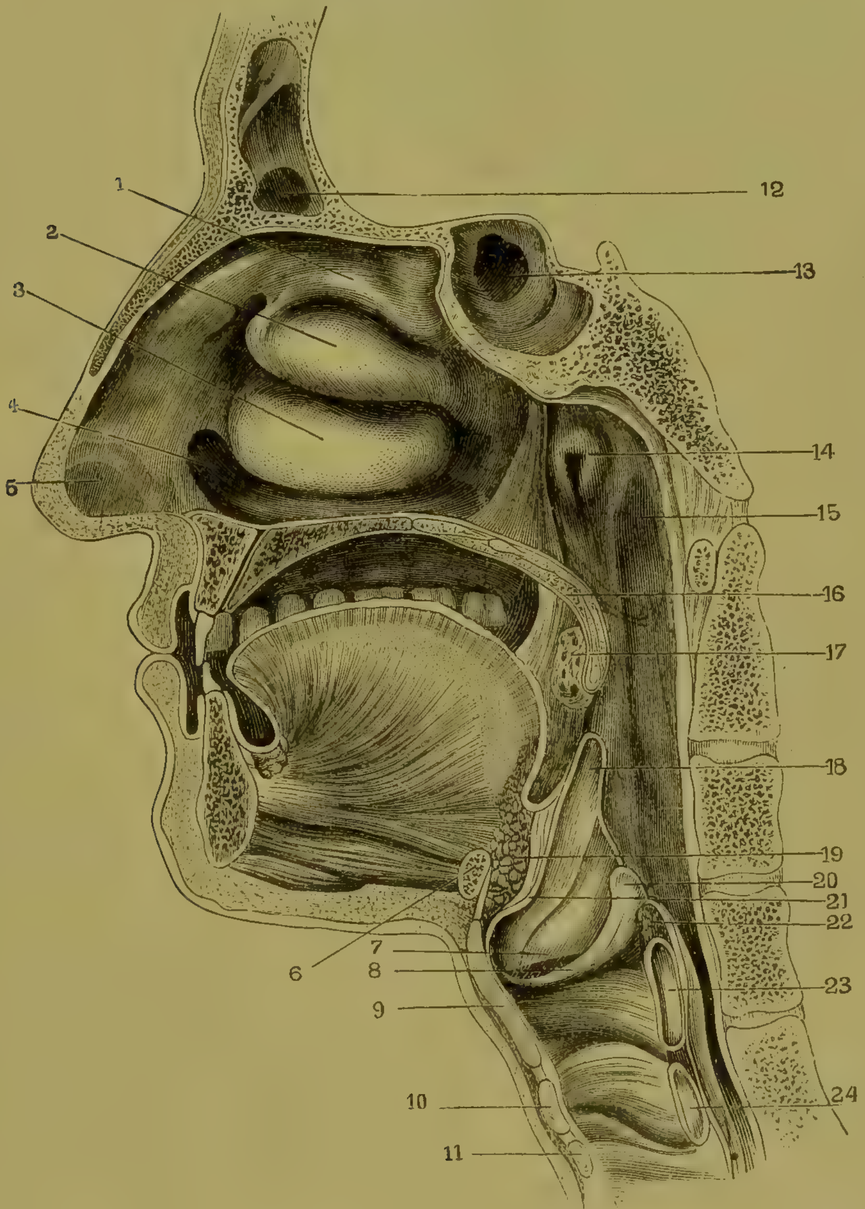
These bands, which are called the vocal cords, present in cross-section the shape of a triangle, the upper side of which is concave, while the inner side is convex, with a small notch below the inner angle.[1] This notch is produced by a folding inward of the mucous membrane below the inner edge of the vocal cord, and is seen throughout its entire length. The greater portion of the section is made up of muscular fibres, while only the inner angle is composed of white fibrous tissue containing a few fibres of yellow elastic tissue. In the female larynx we find a small

[1] The designations of the direction are in regard to the larynx, not to the triangle.

cartilage inserted into this fibrous band, extending from the vocal process of the arytenoid cartilages to nearly the middle of the vocal cords. This cartilage is called the cartilage of Seiler.

A short distance above, and running parallel with the vocal cords, is another pair of folds of mucous membrane, called the ventricular bands,

FIG. 42.



Vertical Section of Head, slightly diagrammatic: 1, superior turbinated bone; 2, middle turbinated bone; 3, lower turbinated bone; 4, floor of nasal cavity; 5, vestibule; 6, section of hyoid bone; 7, ventricular band; 8, vocal cord; 9 and 23, section of thyroid cartilage; 10 and 24, section of cricoid cartilage; 11, section of first tracheal ring; 12, frontal sinus; 13, sphenoidal cells; 14, pharyngeal opening of Eustachian tube; 15, Rosenmüller's groove; 16, velum palati; 17, tonsil; 18, epiglottis; 19, adipose tissue behind tongue; 20, arytenoid cartilage; 21, tubercle of epiglottis; 22, section of arytenoid muscle.

or, before the invention of the laryngoscope, the false vocal cords. Between the vocal cords and the ventricular bands is the lenticular opening of the ventricle of the larynx (Fig. 41).

It will not be necessary to refer to the anatomy of the trachea and

lungs further than to say that the former is composed of incomplete cartilaginous rings contained in a membranous sheath, thus forming a patulous tube which is capable of distension, and that the latter is (as far as its function as a voice-organ is concerned) a large air-bag subdivided by innumerable membranous partitions into a large number of small compartments which are all connected by tubes with the trachea.

The pharyngeal cavity, that portion of the throat which reaches from the upper opening of the larynx to the roof of the posterior nasal cavity (see Fig. 42), presents no particular anatomical features, except that it may be divided into two portions by the soft palate—viz. into an upper or naso-pharynx, and lower or oral pharynx—and that the inferior constrictor muscle of the pharynx by contracting forms a ridge against which the free border of the palate is applied in separating the naso-pharynx from the oral pharynx. The latter may also be slightly altered in its length by the rising or lowering of the larynx in the acts of vocalization and deglutition. Neither is it necessary to say anything about the anatomical features of the oral cavity in this article.

The nose, however, deserves a few words, since its anatomy is greatly slighted in textbooks, and since it has great influence upon the voice.

The nasal cavities, which are wedge-shaped, with a narrow arched roof, extend from the nostrils to the upper portion of the vault of the pharynx. Their outer walls are formed by the nasal process of the superior maxillary and lachrymal bones in front; in the middle by the ethmoid and inner surface of the superior maxillary bones; behind by the vertical plate of the palate bone and the internal pterygoid process of the sphenoid and the turbinated bones. These latter run from before backward, three on each side, and are designated as the inferior, middle, and superior, the latter being the smallest of the three. The spaces or sinuses between these turbinated bones are called meatuses; so that the space between the floor of the nose and the lower turbinated bone is called the inferior meatus, the one between the lower and middle turbinated bones is the middle meatus, and the one between the middle and superior turbinated bones is the superior meatus.

The nasal cavities are separated from each other by a septum or division-wall composed of the perpendicular plate of the ethmoid bone and the vomer posteriorly and the cartilaginous septum anteriorly, thus presenting a smooth surface as the inner wall of each cavity.

The floor is formed by the palatine process of the superior maxillary bone and by the palate bone, and runs in a slanting downward direction from before backward. The roof is formed by the nasal bones and nasal spine of the frontal in front, in the middle by the cribriform plate of the ethmoid, and posteriorly by the under surface of the body of the sphenoid bone. Directly communicating with the nasal cavities by narrow channels are other cavities situated in the bones of the skull: these are the antra of Highmore, large triangular cavities situated in the body of the superior maxillary bone and communicating with the nasal cavities by an irregularly-shaped opening in the middle meatus; then the frontal sinuses, two irregular cavities situated between the two tables of the frontal bone: the communication between them and the nasal cavities is established by the infundibulum, a round opening in the middle

meatus; and finally, the sphenoidal cells or sinuses, found in the body of the sphenoid bone, communicating with the nasal cavities by small openings in the superior meatus.

That portion of the nasal cavities which projects beyond the end of the nasal bone is surrounded by cartilages forming the alæ of the nose.

Into the posterior nasal cavity open the Eustachian tubes on either side, and a mass of glandular tissue is situated on its roof, extending into the naso-pharynx, which is termed the pharyngeal tonsil.

After this short sketch of the anatomical relation of the parts concerned in the production of the voice we must consider a few acoustic laws before we can enter upon the mechanism of vocalization.

Acoustics.—Sound is a vibratory motion of the air producing waves, or a sequence of condensation and rarefaction of the air, which on striking upon the tympanic membrane of the ear gives rise to the sensation called sound. This vibration is produced in turn by any body which executes a rapid to-and-fro motion; in other words, which vibrates. Sounds differ from each other—1st, in pitch, or the position of the tone in the musical scale, which depends upon the rapidity of the vibration and is determined by the length of the wave; 2d, in loudness, which depends upon the largeness or amplitude of the vibration and air-wave; and 3d, in quality or character, which depends upon the form of the vibration or wave.

No sound which we hear except the sound of a tuning-fork is simple, but all single sounds are composed of a fundamental tone which determines the pitch, and of a greater or less number of overtones, which by the unaided ear are not audible as such, but which in mingling with the fundamental tone change the form of the wave and thus influence the character of the sound.

The original vibrations producing the sound-waves may be produced by any body which possesses elasticity, such as a steel rod, or to which elasticity has been imparted by stretching, as is the case with strings. Even a column of air confined by resisting walls, but communicating with the outer air, may under certain circumstances become a vibrating body. Since strings or string-like bodies and a column of air are the vibrating bodies in voice-production, we will inquire a little more closely into the acoustic laws governing them.

A string in order to be able to vibrate and to give forth sound must be stretched between two resisting points, and must be set in vibration by some force external to it. The longer the string is, the lower will be the pitch of the tone, and this pitch can be raised by shortening the string. The greater the power by which the string is stretched, the higher will be the pitch; and finally, the thicker and heavier the string, all other conditions being the same, the lower will be the pitch.

A column of air or gas being, to all intents and purposes, a string of a lighter material, obeys the same laws, with the exception that being elastic it need not be stretched nor can the pitch be changed by stretching. This is compensated for, however, by the fact that the pitch of a column of air may be changed by altering the size of the opening by which it communicates with the outer air; and it is a law that the larger

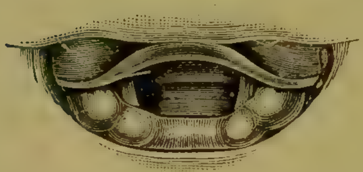
the opening the higher the pitch, and the smaller the outlet the lower will be the pitch.

The sound of an elastic body, such as a string or membrane, when vibrated in close proximity to a cavity filled with air, causes the air to vibrate, and the amplitude of the wave being thus increased the sound is made louder. This is called "resonance," and its best effect—viz. the greatest volume of sound—is obtained when the column of air is made to vibrate with the same velocity as the string; in other words, when the string and air-column are tuned alike. The effect of resonance upon the character or quality of the sound is very noticeable, and depends upon the fact that through changes in the form and shape of the air-column some of the overtones can be strengthened or favored, while others are weakened or extinguished altogether, thus changing the shape or form of the wave.

Voice-Production.—Having thus briefly reviewed the anatomical features of the organs of vocalization, as well as the necessary laws of acoustics, we are prepared to examine into the process of voice-production as it goes on in man.

The first step is the inhalation of air into the lungs, or inspiration. This air is then allowed to flow gently through the bronchial tubes into the trachea by a mild expiratory effort until it reaches the vocal cords. These during respiration are held asunder, so that they allow the air to flow freely through the large triangular space between their free edges, which is called the glottis; but as soon as vocalization is attempted they are approximated until the glottis is reduced to a narrow chink; and this is effected by the approximation and inward rotation of the arytenoid cartilages, to which the vocal cords are attached. (See Figs. 43, 44.) The narrowing of the glottis presents an obstacle to the

Fig. 43.



Laryngeal Image during Respiration.

Fig. 44.

Laryngeal Image during Phonation.

outflowing air-current, and since the vocal cords are also slightly stretched and thus made elastic, they are bulged upward by the pressure from below until their elasticity overcomes the pressure, when they fly back to their normal position. This motion is repeated in rapid succession, and thus the vocal cords are set in vibration; which can readily be seen in the laryngoscopic mirror, by means of which all the changes that take place in the vocal cords during vocalization have been observed. Dr. T. R. French of Brooklyn by means of his ingenious apparatus for photographing the interior of the larynx has produced some excellent pictures of the vocal cords during vocalization, which verify the observations made by the laryngoscope, and which

show the different positions taken by the cords in the different registers of the voice, as described farther on.

The vibration of the vocal cords alone gives but a very feeble and disagreeable sound, as has been clearly demonstrated by experiments on the larynx removed from the body and in cases of wounds of the neck exposing the vocal cords and separating them from the resonant cavities above. What is more, the compass of the voice—*i. e.* the number of tones of different pitch—is very limited, comprising but a few tones of the musical scale. The sounds produced by the vocal cords alone are very similar in character and variety, as well as in number, to those produced by the double reed of a bassoon or hautboy when it is vibrated alone and detached from the instrument. As soon, however, as a column of air is brought in contact with it, this latter becomes a self-sounding body, and not only increases the volume and number of the tones, but also changes their character or quality. The same is the case with the vocal cords, which in causing the column of air contained in the pharyngeal and oral cavities to vibrate, makes it a self-sounding body, and thus volume and character are added to the sound. This is still more increased by the vibration of the air contained in the cavities of the naso-pharynx and nose, which, although separated from the direct influence of the vibrations of the vocal cords by the adaptation of the soft palate to the pharyngeal wall, or rather to the ridge produced by the lower constrictor muscle of the pharynx, still partakes of the vibratory motion, and adds volume and quality to the sound, just as the air contained in the body of a violin adds greatly to the tone of the instrument.

The pharyngeal cavity can be changed in size by the rising and falling of the larynx in the throat, and the oral cavity can also be changed in its dimensions by the action of the tongue, the cheeks, and the lower jaw; and these cavities can thus be attuned to the pitch of the sound produced by the vibration of the vocal cords, whereby, as was shown above, the best effect of tone is obtained.

But the oral cavity can also be tuned to a definite pitch by the changeable opening of the lips, as well as by the motion of the tongue and cheeks, and thus still another means is provided for this purpose. This adjunct is of great importance, not only in articulation, as will be seen later on, but also in vocalization; for in order to produce a low pitch the cavity of the mouth would have to be made as large as possible, which can be done only by depressing the tongue to its utmost, thus pushing the root down upon the larynx and encroaching upon the pharyngeal cavity, which would not only materially interfere with the activity of the laryngeal muscles, but would also hinder the free vibration of the column of air. But since a cavity of air can be tuned lower by making the opening by which it communicates with the outer air smaller, and *vice versâ*, the cavities can be tuned to even the lowest tone of the voice by slightly closing the lips and making the cavities as voluminous as possible without interfering with the free motion of the air contained in them.

This attuning of the resonant cavities above the vocal cords, although natural to man, requires considerable practice for its full development,

and it is the quickness and precision with which the different movements are executed in these cavities which makes what is called a "trained voice." It naturally follows that a voice weak in volume and deficient in quality can be made to sound stronger and more agreeable by such training. On the other hand, a naturally good and strong voice may materially be altered for the worse by interfering with the oral resonance, be it by the use of too much breath, or by a faulty attuning of the resonant cavity, or, finally, by permanent alteration of this cavity by growths, paralysis of the soft palate, or a faulty artificial denture.

There are in every voice, both male and female, certain divisions which can be differentiated from each other both by the volume and quality of the individual tones within the limit of the division, and these have been termed "registers" of the voice. They are variously designated by singers and teachers of vocal music according to their fancy, but we will, for the sake of simplicity, accept those terms which are most generally used. Thus, the voice is divided into—1, the lower chest register; 2, the upper chest; 3, the falsetto; and in the female voice we find also a second falsetto, and finally a head register. These names are derived from the feelings which a singer experiences during the act of vocalization in the different registers. Thus he feels as though the voice came from the lower part of the chest in the lower division; a little higher up, in the second; from the throat in the falsetto, which is therefore also frequently called the throat register; or from the top of the head in the head register.

Let us now examine the movements of the vocal cords more closely during the act of vocalization, particularly when the subject of our examination sings up the scale, commencing with the lowest note of his voice, and we will see that these divisions of the voice are not merely based upon the subjective impressions received by the ear of the listener, but are dependent upon important changes which take place in the position and movements of the vocal cords themselves.

As we have already seen, the vocal cords are stretched between their attachments, and are brought together by the approximation and inward rotation of the arytenoid cartilages as soon as an attempt at vocalization is made. If now the singer whose larynx we observe with the laryngeal mirror sings the lowest tone of his voice, the first tone of the chest register, we see that the glottis or chink between the free edges of the vocal cords has the shape of an ellipse, and that the cords vibrate slowly in their entire length and width; in fact, the walls of the larynx itself participate in the vibratory motion. As soon as the next tone in the scale is attempted, the arytenoid cartilages with a quick motion fly asunder and come together again, but a little closer than before, making the glottis slightly narrower, and the cords are at the same time stretched a little more. This is repeated with every successive tone in the scale until the limit of the register is reached, when at the next tone, the first in the higher division, the arytenoid cartilages remain closed, and the participation of the laryngeal walls in the vibratory movement ceases. The vibration of the cords is also less apparent, because quicker and less violent, but still they vibrate in their whole length and width.

At the end of this register a very noticeable change takes place, for with the first tone of the falsetto or throat register the glottis, which hitherto was comparatively wide, is reduced to a mere slit, and only the narrow edges of the cords vibrate, which seem quite thin and sharp. This is produced by the unfolding of the fold below the edge of the cord which was described above, and by the contraction of the muscular fibres forming its body. As in the lower chest register, the arytenoid cartilages again fly asunder, but the motion is performed so quickly as to escape notice in many cases. In the female voice—and but rarely in the male—a second falsetto is noticed, which, like the second chest register, differs from the first falsetto merely in the fact that the arytenoids remain in close juxtaposition, while the cords are stretched tighter with every successive tone.

Finally, the head register is reached, which is peculiar to the female voice, and with its flute-like tones is due to the posterior portion of the glottis being completely closed by the apposition of the cartilages of Seiler, while only the anterior portion of the cords vibrates, thus making the vibrating cords shorter and increasing the pitch of the tone. With every successive tone this shortening process progresses, until at the highest tone of the female voice only a small elliptical opening at the anterior portion of the glottis, the edges of which vibrate, allows the air to pass through.

In the so-called whispering voice the action of the vocal cords, according to Rossbach and other investigators, is different from loud vocalization, and by the laryngoscope it is observed that the anterior portion of the vocal cords are approximated until they overlap, while the posterior portion of the glottis, which is bounded by the vocal processes of the arytenoid cartilages, is open, and allows the air to pass, setting its rigid edges into irregular vibrations, much in the same manner as the lips are vibrated in soundless whistling. As a matter of course no sound, as such, is produced by the vocal cords, and any changes in the pitch and quality of the whispering noise which can be observed are imparted to it by changes in the resonant cavities above the vocal cords. Thus the whispering voice, or the noise produced by the rush of air through the triangular opening of the glottis, may be utilized with advantage in studying the changes in the resonant cavities and in determining the pitch to which they are tuned in some of the sounds of articulate speech.

Pathology.—There is a great variety of conditions produced by disease or accidents which will interfere with the function of vocalization, some of which deserve to be mentioned in these pages.

If from any cause, be it by the introduction of a foreign body into the larynx or through inflammation of the parts or through the presence of a tumor, the vocal cords are prevented from either vibrating or from being approximated, hoarseness or total loss of voice results, which remains until the existing cause is removed. In many cases of loss of voice or hoarseness—which latter condition of the voice is different from aphonia or total loss of voice merely in degree, and not in kind—we find that paralysis of the muscles of the larynx is the cause, and that thus the cords are either not approximated sufficiently or else they are

not made tense enough to vibrate audibly. This is frequently observed in singers or speakers who by over-exertion have weakened the laryngeal muscles, and also in individuals of an hysterical tendency, and can be relieved only by careful treatment, directed to the parts affected, at the hands of a skilful laryngologist. And, finally, there are cases in which, through ulceration and the consequent loss of tissue, or through the subsequent cicatricial contraction or adhesion, the vocal cords are prevented from presenting the obstacle to the outflowing air-current necessary to set them in vibration, and thus hoarseness or loss of voice is produced. This condition is usually found in phthisis, syphilis, lupus, and after the accidental inhalation of caustic fluids and other traumatic injuries of the larynx. Temporary hoarseness, or aphonia, is noticed in most cases of laryngitis, and is due to inflammatory infiltration, either into the tissue of the cords themselves or into the tissue of the muscles moving the vocal cords, or both, and if not speedily relieved by appropriate treatment frequently becomes chronic and leads to permanent impairment of the voice more or less grave.

The voice is not only interfered with by changes in the texture and mobility of the vocal cords, but also by changes in the resonant cavities of the pharynx, mouth, and nose. While hoarseness or aphonia—that is, diminution of the compass of the voice and loudness of tone—is produced by the inability of the vocal cords to vibrate in a normal manner, we find that changes in the resonant cavities affect chiefly the quality of the voice, and its loudness only to a limited extent. Thus if, for instance, a swelling or tumor exists in the pharyngeal mucous membrane just above the larynx, the voice sounds muffled, as though it were retained in the throat and could not reach the outer air, thus losing in reach—that is, the distance at which it can be heard—and in quality. The same effect is produced when through bad training the tongue is pushed back upon the larynx in singing and thus produces what is called a "throaty" voice, so often heard on the stage and in the concert-room. If the faucial tonsils are enlarged, a considerable space is taken up by them in the oral cavity, where it communicates with the pharyngeal cavity, and thus the tuning of the former cavity to the pitch of the vocal cords is made difficult, giving the voice a peculiar quality, such as is produced by a person singing with food in the mouth.

Enlargement of the pharyngeal tonsil has a peculiar effect upon the voice, inasmuch as it does not materially interfere with its lower notes, except perhaps that they are not as strong as they were before the enlargement of the gland took place; but it makes the higher chest notes in the male and the head tones in the female almost impossible. To give a scientific reason for this phenomenon would carry us altogether beyond the limits of this article.

Paralysis or loss of the soft palate, congenital or by disease, or merely perforation of this organ, interferes with the complete separation of the oral pharynx from the naso-pharynx and nasal cavity, and has the effect of interfering to some extent with the nasal resonance, making the sound of the voice what is erroneously termed "nasal;" but this, like the obstructions in the nasal cavities by tumors or localized swellings of the turbinated tissue so common in nasal catarrh, is less notice-

able in vocalization than in articulate speech, under which section it will be referred to more in detail.

Finally, paralysis of the tongue, which of course has great influence upon articulation, also materially affects pure vocalism without words, inasmuch as the tongue is the main organ by which the tuning of the oral cavity is affected.

Articulation.

In the foregoing pages we have considered vocalization or voice-production without words, and it now remains to describe the method by which the various sounds are produced which when uttered consecutively in a certain order produce what is termed "articulate speech." Since this article is written in the English language, and will be read mostly by English-speaking readers, all those sounds which enter into the composition of other languages and are foreign to English will be omitted.

From time immemorial grammarians have divided the sounds of articulate speech into two classes—viz. vowels and consonants; and this division will be retained for the sake of simplicity and convenience in the following description, but be it understood that in reality there is no such class distinction in speech. Startling as this may seem, yet this statement is true and borne out by experiments and close observation; for if we listen to a speaker we do not hear him pronounce vowels and consonants separately, but we hear separate sounds forming the syllables, which consist of the vowel sounds altered in quality by noises or in duration by the more or less sudden cessation of the sound. Several years ago the author verified this observation by experiments carried on by means of one of Edison's loud-speaking telephone-receivers in the following manner: In the centre of the mica diaphragm was fastened a delicate stylus made of the end of a swan's feather, the tip of which rested upon the surface of a cylinder covered with smoked paper. This cylinder, being revolved, travelled at the same time from right to left, so that the stylus when at rest would draw a continuous line in the form of a spiral upon the paper. An assistant at the other end of the telephone line, several hundred feet away, would then speak into a transmitter in connection with the receiver, thus causing the mica diaphragm to vibrate and agitate the stylus, which latter drew a series of curves instead of a straight line upon the smoked paper. In the course of the experiment it was found that each of the five elementary vowels gave a distinct curve, which, although altered by the admixture of the consonants in the pronunciation of a syllable, still retained its characteristics. In those syllables in which the consonant noise is sounded either before or after the vowel sound, as in "as" and "saw," the irregular *s* curve was seen to merge into and mingle with the regular curve of "ah," either at its beginning or end, thus giving the vowel sound its peculiar character as heard when these syllables are pronounced.

Recently, Dr. Harrison Allen has made some experiments to determine the action of the soft palate in articulate speech, and has by an

ingenious method succeeded in obtaining tracings of the motion of this organ. The curves which he obtained, and which are produced by the vibration of the velum transmitted to a long lever, one end of which rests upon the upper surface of the palate while the other end projects from the nostril and touches the smoked paper, give only the upward motion of the organ, and are therefore incomplete; yet they also show to some extent this admixture of consonant and vowel sounds with the preservation of the vowel characteristics. And, finally, Prof. E. W. Blake obtained similar curves showing the composite character of the sounds of articulate speech by photographing the vibrations of the telephone diaphragm by means of an ingenious method which he describes in *Silliman's Journal* for July, 1878.

The mechanism by which articulate sounds are produced is a very complex one, and for the sake of clearness in the description of the several parts the division of speech into vowels and consonants will be retained in this article.

THE VOWELS.—The vowel sounds are those sounds of articulate speech which are primarily produced by the vibration of the vocal cords, the character of the sound being modified in a definite manner by the resonant cavities. Thus, the vowel sound *Ah* as in "father" is produced by the sound of the vocal cords, and this sound is modified by the peculiar position of the different parts forming the resonant cavities, in such a manner that the ear of the listener recognizes the sound as the vowel *Ah*, no matter whether the pitch of the sound of the vocal cords changes from high to low or remains stationary. It is not the position of the sound of the vocal cords in the musical scale which distinguishes one vowel from another, but the peculiar quality given to it by the resonant cavities. That this is so is proved by the investigations of Donders, Helmholz, Wolff, Seiler, and others, who all agree that in the production of vowel sounds the resonant cavity of the mouth and pharynx is tuned to a definite pitch, which never varies more than a fraction of a tone for the same vowel. And it has also been found that no matter whether the vowel is pronounced by a full-grown man, a child, or a woman, or even by members of different nations, the pitch of the resonant cavity is the same in all instances, provided, of course, that the vowel sound is the same. The discrepancy in the size of the cavity in the several instances is equalized by the greater or less degree of the opening of the mouth, so that the small oral cavity of the child can be tuned to the same pitch as that of the larger one of the man. The reader can verify this by experiment in the following manner: Let him pronounce in a whisper the vowel sound of *OO*, and while doing so let him tap his cheek with a lead-pencil; he will then obtain the pitch of the resonant cavity. Let him now change the pitch of this cavity by opening or closing the lips, and then whisper again, and he will at once find the character of the vowel to be changed so as to approach that of another vowel.

This tuning of the resonant cavity to a definite pitch determines the character of the vowel sound by favoring the development of some of the overtones of the vocal sound, while it makes the sounding of other overtones impossible; and as it has been shown above that the character

of the sound depends upon the shape of wave which is produced by the addition of the overtones to the fundamental tone, it follows that if only certain overtones are added to the exclusion of all others, the resulting wave will have always the same shape and the sound always the same character.

The fact, as shown by the experiment, that a change in the tuning of the resonant cavity changes the character of the vowel sound so as to approach to that of another vowel, leads us to think that all the vowels are but modifications of one elementary vowel. The elder Du Bois-Raymond already recognized this fact, and determined upon the *Ah* as the elementary vowel from which all other vowels are derived. He took this vowel sound as the foundation because it is the natural result of the vibration of the vocal cords in connection with a resonant cavity in which there are no obstacles to the even outflow of the sound. In other words, the parts of the resonant cavity remain in a quiescent state as in normal respiration, and the lips are widely separated, so that a funnel-shaped tube extending from the glottis to the lips is thereby established.

In referring to Fig. 45, which is a diagrammatic outline of the resonant cavities and of the larynx in section, it will be seen that in the

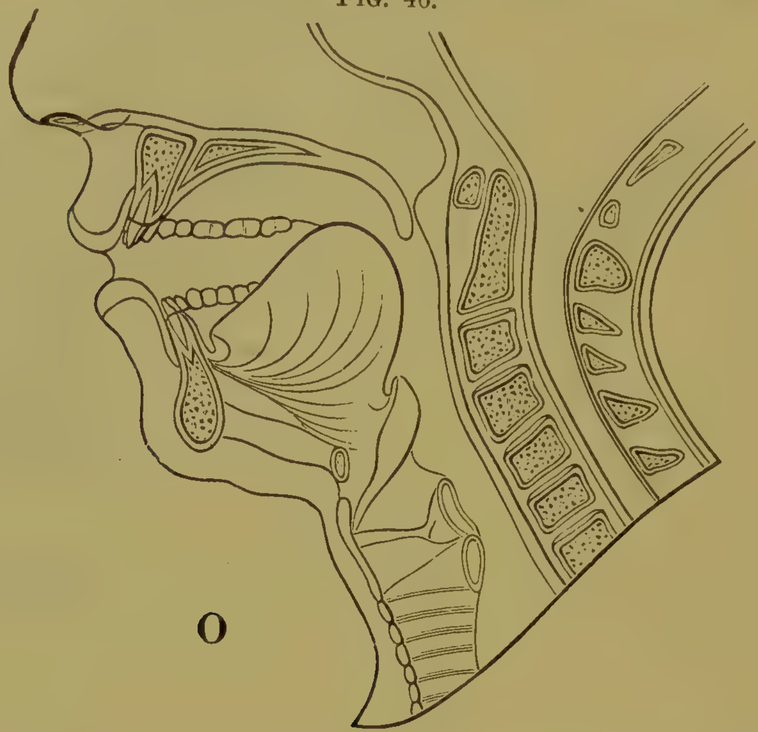
Fig. 45.

pronunciation of the vowel *Ah* the tongue lies flat on the floor of the mouth, the teeth and lips are parted, the velum palati with its uvula touches the projection in the pharynx formed by the pharyngeal constrictor muscles, and thereby closes the opening leading to the nasal cavities, and the larynx is slightly raised in the throat. The pitch of the resonant cavity stands at about the middle between the other simple vowel sounds, and is the $d\flat^2$ of the musical scale.[1]

[1] The figures above and below the letters denoting the tones in the musical scale

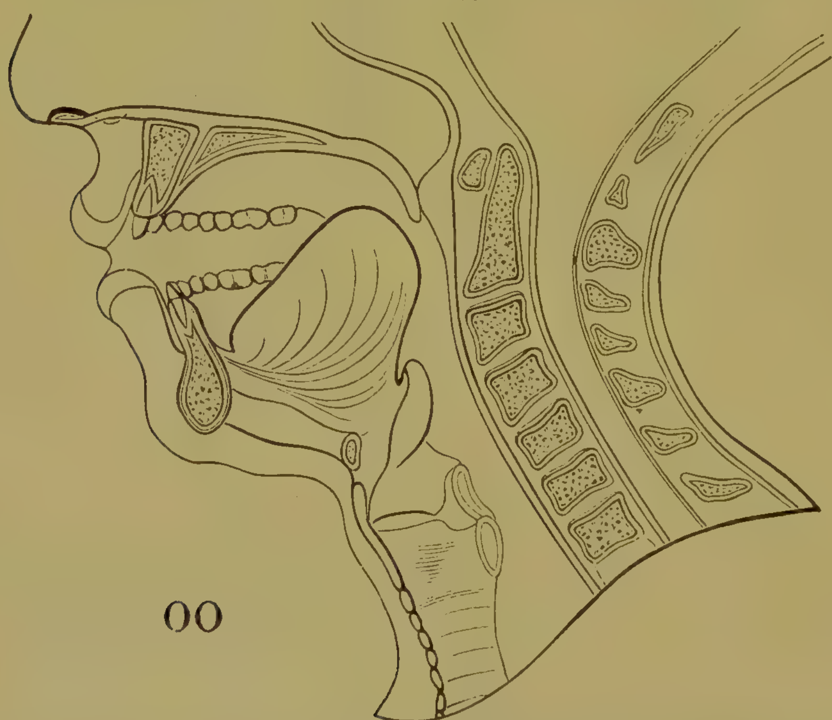
The vowel sound *O* is produced by approximation of the lips, so that the opening between them becomes smaller than in the pronunciation of

Fig. 46.



the *Ah*, and at the same time is circular. The tongue rises at its root, and its tip is retracted from the teeth, so as to make the anterior portion

Fig. 47.



indicate the octave on the piano in which the tone is found, so that the middle C is written *c*, while the octave above is written c^1. The lower octaves are written with capital letters, thus, C, C_1, C_2, C_3.

of the oral cavity as roomy as possible (Fig. 46). These changes would indicate that the pitch of the resonant cavity is lower than in *Ah*, and by experiment is found to be for *O* $a\flat^1$.

The pitch is still lower in the vowel *OO*, because in the formation of this sound the lips are brought together so as almost to touch each other,

FIG. 48.

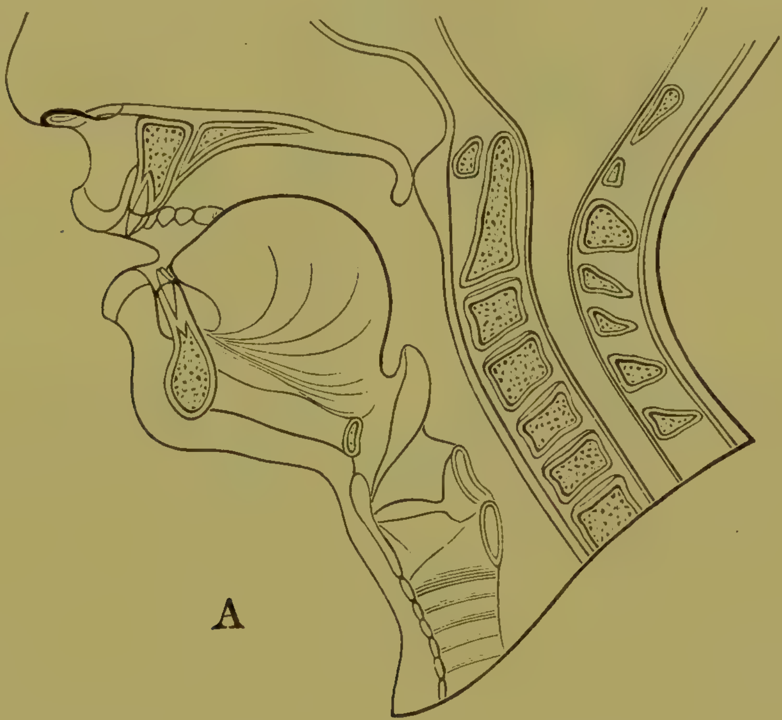
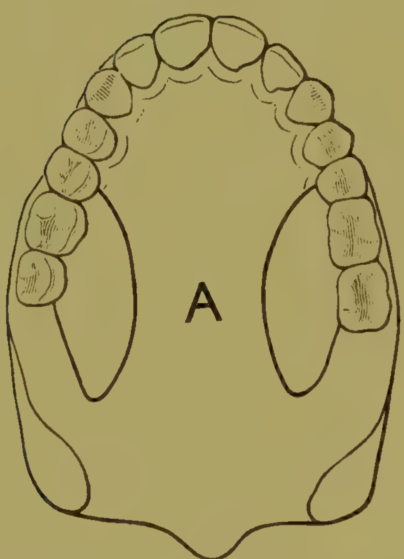


FIG. 49.

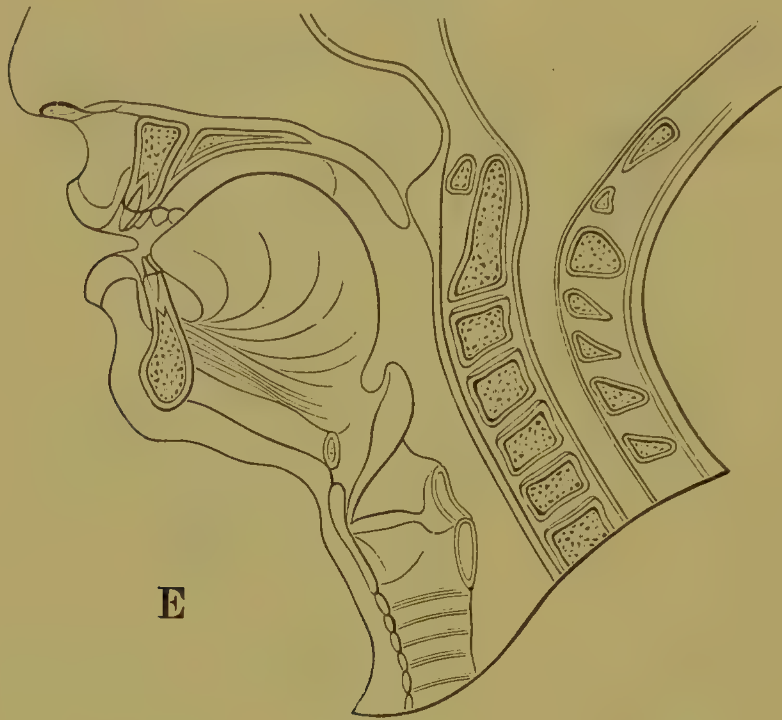


and are slightly protruded, thus forming a narrow oval opening to the oral cavity, the tongue remaining in nearly the same position which it took in the formation of the *O* sound, so that the lowering of the pitch is produced solely by the diminution in the opening formed by the lips (Fig. 47). The pitch of the resonant cavity in the pronunciation of this vowel is *f*.

These three vowel sounds—viz. *Ah*, *O*, *OO*—are called the dark vowels, and the consonant *c* is in most languages pronounced as *k* when either of them follows it in a word or syllable.

Starting again from the *Ah* as the normal vowel, we find that when

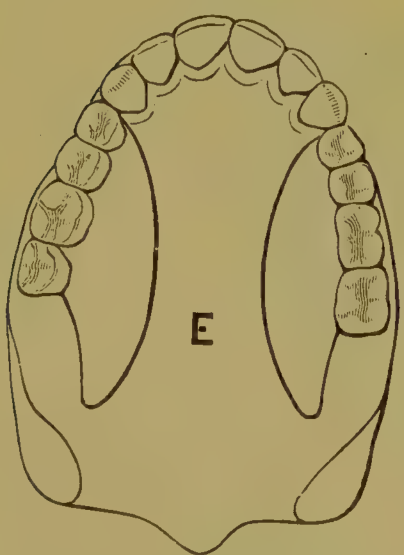
Fig. 50.



the lips and teeth are brought somewhat closer together and the sides of the tongue rise until they come in contact with the roof of the mouth, the vowel sound *A* as in "scale" is the result, and that the pitch of the resonant cavity is raised to $b\flat^2$ (Figs. 48 and 49).[1]

The vowel sound of *E* is formed by a slightly greater approximation of the teeth and lips, the corners of the mouth being at the same time drawn slightly downward, while the tongue rises still more at its edges, touching the palate to such an extent at either side as to leave but a narrow gutter in the middle by which the anterior and posterior portion of the resonant cavity can communicate (Figs. 50 and 51). The pitch of this vowel sound corresponds to the $b\flat^3$ of the musical scale, and is the highest of all these vowel sounds.

Fig. 51.

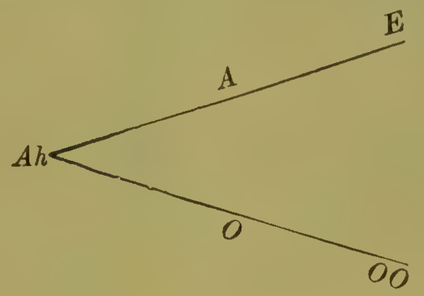


[1] Fig. 49 represents a diagram of the roof of the mouth, and the dark lines on either side the place and extent to which the tongue touches and presses against the roof of the mouth. This impact of the tongue against the palate has been accurately determined by Dr. N. W. Kingsley by means of an ingenious device which he describes in his work on *Oral Deformities*, and by his permission these and the following diagrams have been made from drawings in his book.

By a reference to the diagrams it will be seen that the velum palati is in contact with the ridge formed by the constrictor of the pharynx, and thus closes the posterior opening of the nasal cavity in the formation of these vowel sounds.

The *A* and *E* sounds are termed the light vowels, and before them the *c* is pronounced as *s*.

The relation which these sounds bear to each other can be illustrated by a diagram in the form of a wedge, thus:



The *Ah* sound forms the centre or angle, and as the normal vowel is the starting-point, the light vowels, being of higher pitch, rise above it on the upward plane, while the dark vowels, being of lower pitch, are placed on the downward plane. The *OO* and *E* sounds are the termini, while the *A* and *O* sounds stand between them and the *Ah* sound. It can readily be seen, however, that the qualities of these elementary vowel sounds can be combined, thus forming a new sound, which is called the double vowel or "diphthong," which is so largely used in the Germanic languages. But other combinations may also be formed, in which the characteristics of the component sounds are not equal and the one or the other is predominating, as is the case with the *Ah* sound in many English words, so that some grammarians describe as many as twenty vowel sounds in the English language. They can, however, all be reduced to the five elementary vowels described above, and need not here be considered in detail.

THE CONSONANTS.—As has already been indicated, the consonants are the more or less distinct noises which in articulate speech accompany the vowel sounds, and with them make up the syllables and words. Grammarians have classified them generally according to the anatomical parts of the organs of speech by means of which the noise is produced, as, for instance, into labials, dentals, linguals, and so-forth; but it seems more logical in this article to follow the classification proposed by Dr. Wolff—viz.:

1. Simple self-sounding consonants, which can be sounded and heard without the aid of the vowels making an audible noise. These are the *C*, *K*, and *G*, *P* and *B*, *D* and *T*, *F* and *V*, *S*, *J*, and the *Th* sounds.

2. Compound self-sounding consonants, as the *Sh* and *X*.

3. The simple tone-borrowing consonants, which borrow their sound from the vowel, and are audible only in connection with a vowel sound, as *H*, *L*, *M*, *N*.

4. The compound tone-borrowing consonants, which class contains only two—the *W* and the *Ng* sounds.

These noises are produced by a more or less complete obstruction to

the outflowing current of air, which obstruction takes place in the oral cavity in three principal places: First, by the application of the tip of the tongue to the upper incisors; second, by the application of the back

Fig. 52.

Fig. 53.

Fig. 54.

of the tongue against the velum palati; and third, by the closure of the lips.

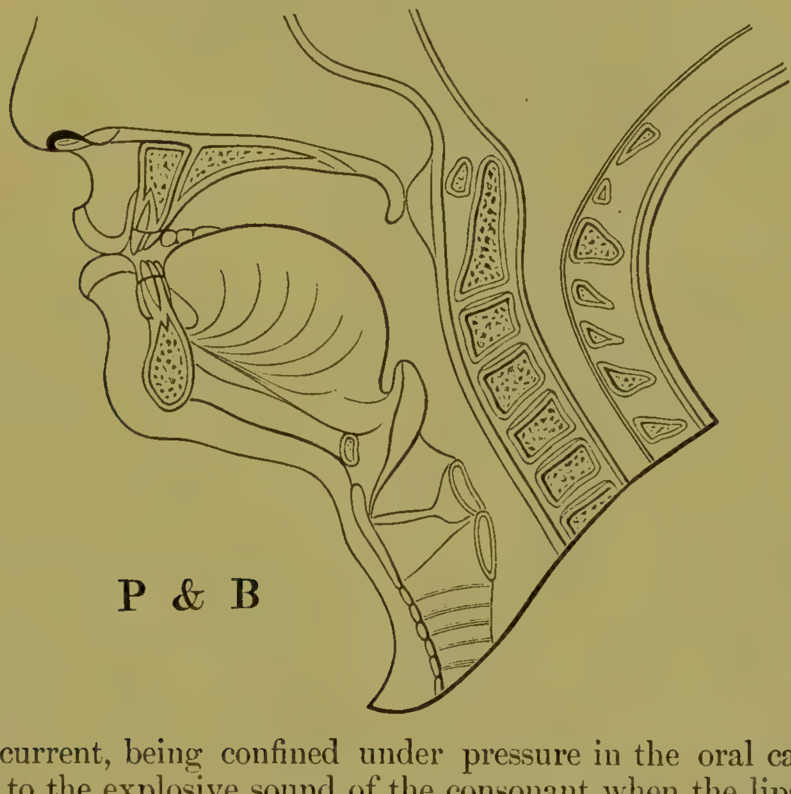
These methods are illustrated by the diagrams Figs. 52, 53, and

54. It will be seen that the oral cavity still retains its resonant quality; in other words, sufficient room is left either before or behind the obstruction in the oral cavity for a considerable quantity of air, which by being thrown into vibrations gives the consonant a pitch which is independent of the pitch of the vowel and the vocal cords, and which never varies in the same consonant. In fact, in the self-sounding consonants, in which the noise is quite loud, this pitch can readily be determined by the unaided ear when the consonant is whispered.

The mechanism of the production of these consonant sounds is quite complicated, and it will be necessary to describe it for each sound in detail.

1. *The Simple Self-sounding Consonants.*—The *P* and *B* sound is formed by the outflowing current of air meeting with an obstacle presented by the closed lips. The teeth are slightly separated, the tongue lies quiescent in the floor of the mouth, and the velum palati is applied against the wall of the pharynx, thus closing the nasal cavity (Fig. 55).

FIG. 55.



The air-current, being confined under pressure in the oral cavity, will give rise to the explosive sound of the consonant when the lips are suddenly parted, or if the consonant occurs at the end of a syllable or word when the lips are suddenly closed. The difference between the *P* and the *B* sound consists in greater air-pressure and more sudden opening or closing of the lips in the formation of the *P* than when *B* is pronounced. This also gives rise to a slight variation in the pitch of the tone to which the cavity of the mouth is tuned, so that the pitch for *P* is $f = 346$ vibrations in the second, and that of *B* is $e = 320$ vibrations.

In the *K* and *G*[1] sounds the closure of the oral cavity is produced by the back of the tongue, which rises until it comes in contact with

[1] The *g* is the so-called "hard *g*," as it is pronounced before the dark vowels, *a*, *o*, *u*.

the velum palati; which latter is in contact with the pharyngeal wall. Both the teeth and lips are slightly parted, and the explosive sound is produced by the more or less sudden application of the

Fig. 56.

tongue to the velum (Fig. 56). In the pronunciation of the *G* the tongue touches a larger area of the velum than is the case in the formation of the *K* sound, as will be seen by consulting Figs. 57 and 58. At the same time, the air-pressure in the *G* is not as great, nor

Fig. 57.

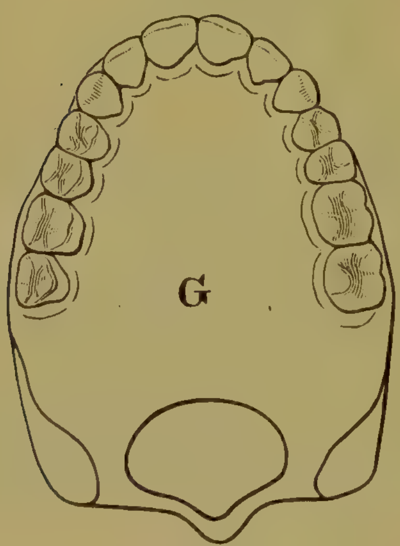
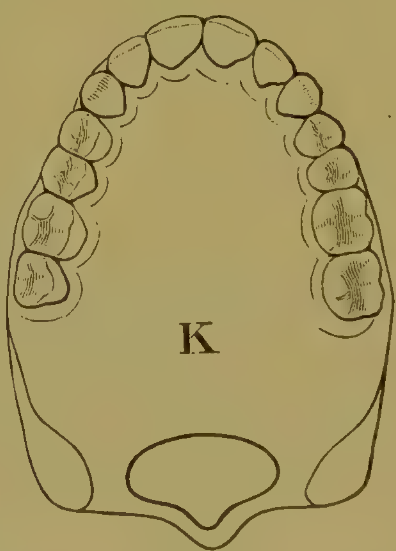


Fig. 58.



the impact of the back of the tongue against the top of the palate as sudden, as it is in the *K* sound. This, as in the case of the *P* and *B*, produces a slight difference in the pitch of the sounds, which for the

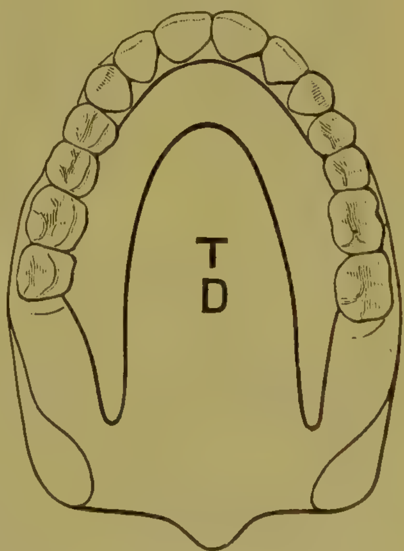
G comes close to $d^2 = 582$ vibrations; while that of the K lies nearest to $e\flat^2 = 614\frac{1}{2}$ vibrations.

The third method of producing an obstruction in the oral cavity to the outflowing air-current is utilized in the formation of the T and D

FIG. 59.

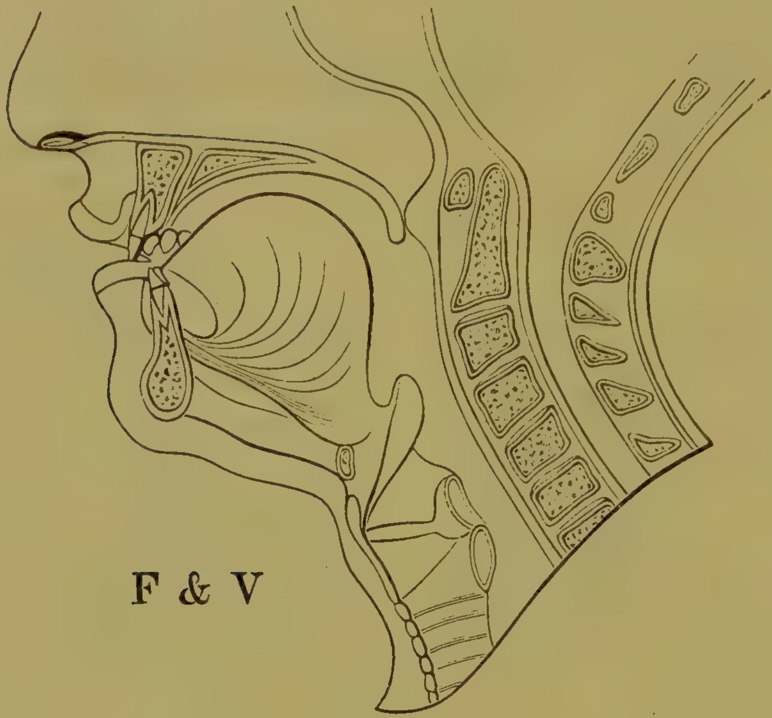
sounds, where the tip of the tongue, as well as its edges, are applied closely to the alveolar border of the upper jaw, and somewhat beyond it against the hard palate, as is illustrated in Figs. 59 and 60. The lips and teeth are again slightly parted, and the air-current is more or less suddenly interrupted, which, as in the case of the foregoing consonant sounds, produces the difference between the two sounds. The pitch of the D sound lies nearest to $f\sharp^2 = 726$ vibrations; while the T sound approaches the tone $g^2 = 776$ vibrations. Here, again, we notice the difference in the pitch of the proper tone of the consonants produced by the greater or less air-pressure.

FIG. 60.



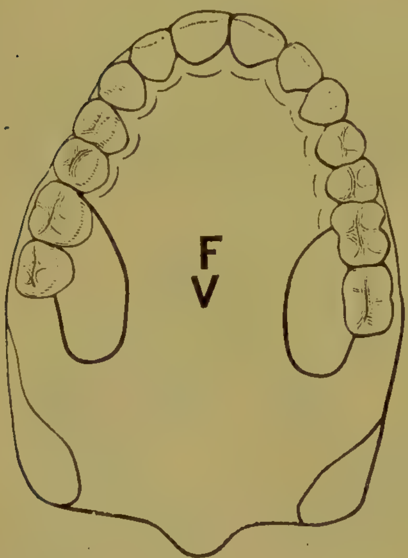
In the formation of the F and V sounds the under lip is gently laid against the edge of the upper incisors, the tip of the tongue pressed against the inner surface of the lower incisors, and the middle portion of its edges are applied to the posterior portion of the alveolar border of the upper jaw, while the velum, as in the foregoing sounds, closes the posterior nasal orifice by pressing

Fig. 61.



against the wall of the pharynx (Figs. 61 and 62). By this arrangement of the parts a gutter is produced for the flow of the air-current, which is thereby directed toward the closure produced by the under lip and upper incisors. This closure being, however, capable of but little resistance, the air forces its way through, and sets the edges into irregular vibrations, and thus produces the *blowing* sound of *F*. The proper tone or pitch of this sound is very close to $a^2 = 864$ vibrations. A more gentle flow of the air-current through the gutter and past the obstruction produces the *V* sound, the proper pitch of which cannot be accurately determined, owing to the want of loudness of the tone and presence of many of the higher overtones; but, judging from analogy, its pitch should be about a half tone lower than that of the *F*.

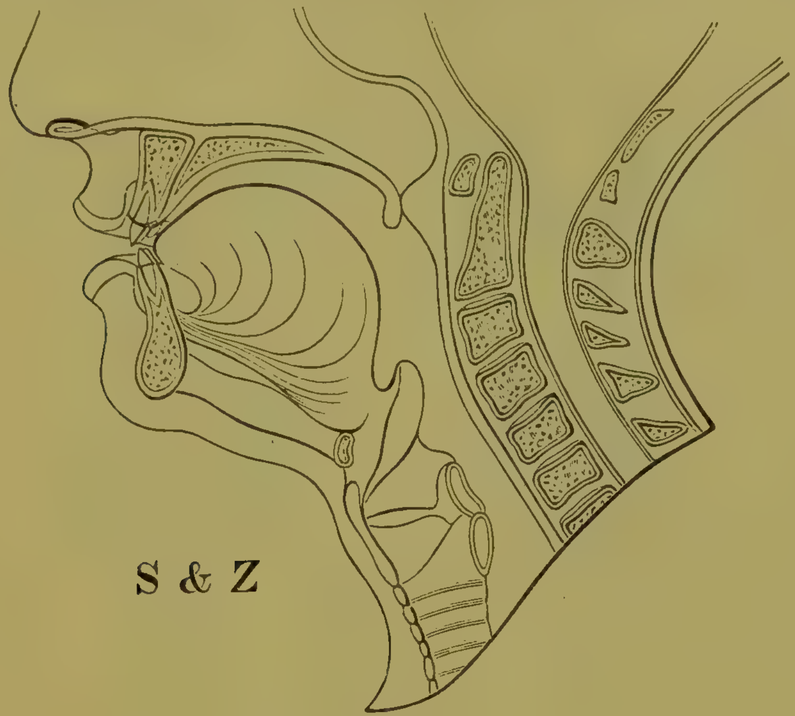
Fig. 62.



Similar to the *F*, the *S* sound is formed by a continuous flow of breath past an incomplete obstruction, the edges of which are set in vibration. So we find that in the pronunciation of the *S* the teeth are brought almost in contact with each other, leaving a narrow slit between them; the lips are slightly parted, the tip of the tongue rests against the inner surface of the lower incisors, and its edges are pressed against the whole length of the dental arch of the upper jaw, thus forming again a gutter between its middle and the palate. The velum closes

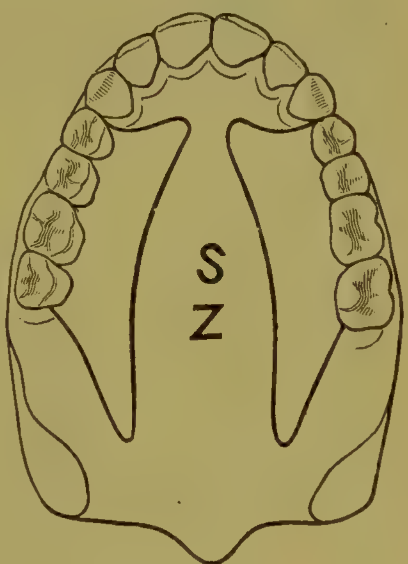
the posterior nasal orifice to prevent the escape of the breath through

FIG. 63.



the nose (Figs. 63 and 64). The pitch of this sound, on account of the small space of air in the oral cavity, is very high, corresponding to $b\flat^4 = 3666$ vibrations per second. The description of the formation of the *S* sound comprises in itself, as a matter of course, the *Z* and the *C* when placed before the light vowels *E* and *I*, which differ from the *S* only in the greater or less force of the outflowing breath.

FIG. 64.

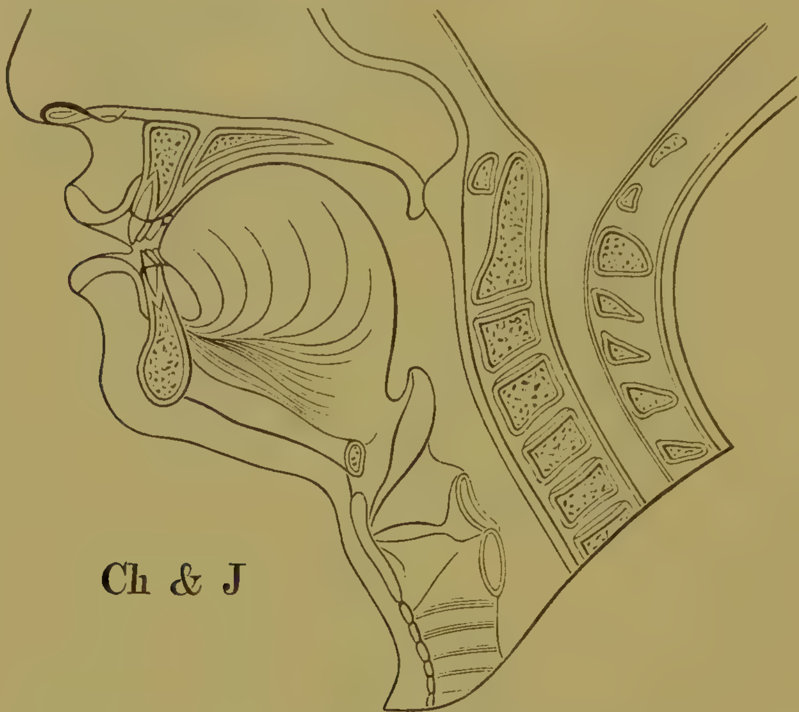


The *J* sound also comprises several consonants—viz. the *Ch* and *G* sound when placed before the light vowels—and differs from it only in the greater or less force with which the air-current is driven past the obstruction. The *J* is formed by the anterior portion and the edges of the tongue being laid gently against the palate and the alveolar borders of the upper jaw; the lips are parted, the teeth are slightly separated, and the velum pressed against the pharyngeal wall (Figs. 65 and 66). In this way, again, a gutter is formed for the breath to flow through, which ends on a line slightly back of the cuspid teeth, and the air has to force its way between the palate and the anterior portion of the tongue. The pitch of the proper tone of this sound is, as in the *S* sound, very high and approaches closely to $d^4 = 2328$ vibrations.

Closely resembling the *S* sound in many ways is the *Th* sound, which

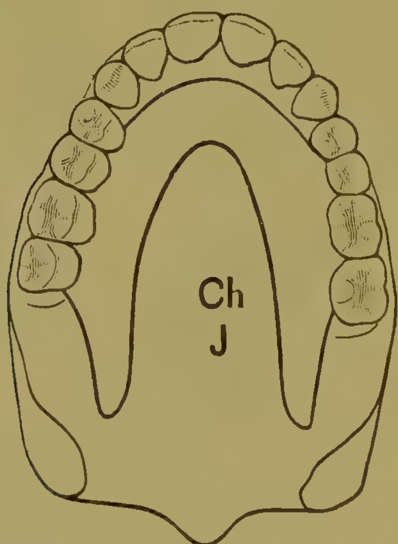
is formed by the tip of the tongue being pushed out between the incisor teeth, while its edges are applied to the alveolar borders of the upper jaw, forming again the channel for the direction of the air-current,

FIG. 65.



which is prevented from escaping through the nose by the velum being pressed against the pharynx. The lips are parted to give free egress to the air after it has passed the obstruction presented by the tip of the

FIG. 66.



tongue and the upper incisors (Figs. 67 and 68). The breath as it passes this obstruction causes a slight irregular vibration of the edges of the teeth, which gives rise to the blowing sound which is so difficult for foreigners to acquire. The pitch of the proper tone of the *Th*

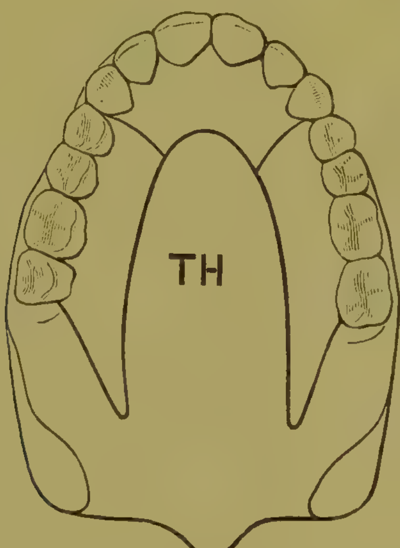
sound is about a tone lower than that of *J*, and corresponds to the $c^4 = 2112$ vibrations per second.

The last of this class of consonants is the *R* sound, which, however,

FIG. 67.

differs from all other consonants, inasmuch as it can be produced in two different ways. Almost all English-speaking people pronounce this consonant with the back of the tongue, but so indistinctly that it

FIG. 68.

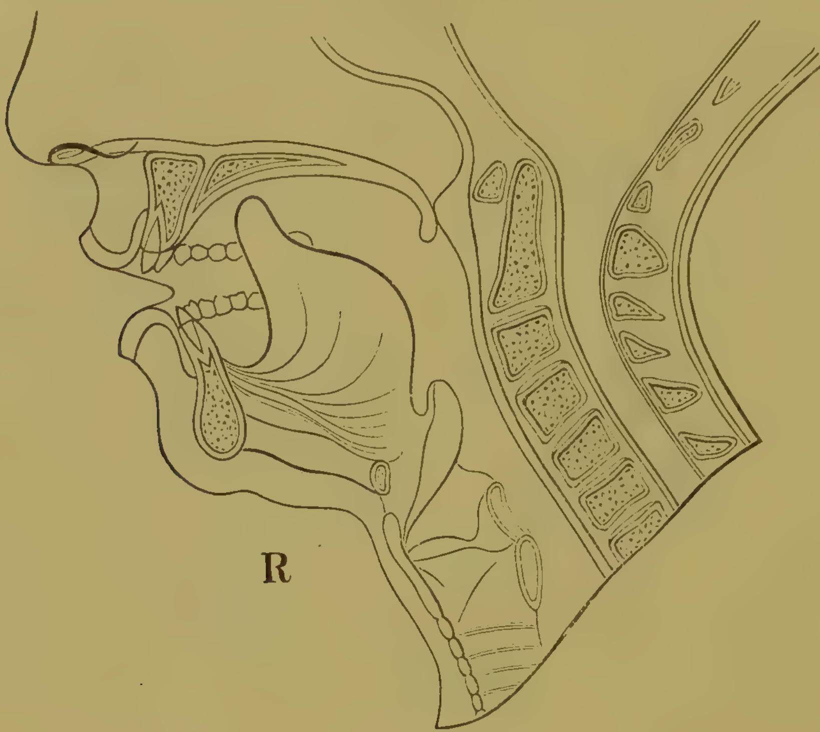


is barely audible, while the *r* in most other languages is made with the tip of the tongue and is quite audible as a self-sounding consonant. The first is called the "guttural *r*," while the other, the correct sound, is termed the "lingual *r*."

The "guttural *r*" is produced by the back of the tongue being placed

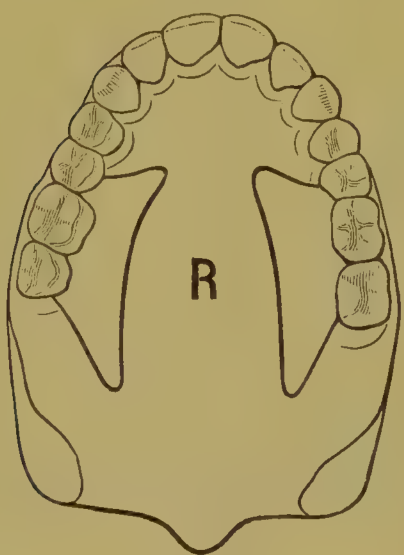
gently against the velum in the same place as in the *G* (Fig. 57). The posterior nasal orifice is closed by the velum, and the uvula is allowed

FIG. 69.



to hang down and lie on the tongue. The current of air is then forced past the incomplete obstruction, and in doing so the uvula is thrown into slow, irregular vibrations, which produce the peculiar fluttering sound. The pitch of the proper tone of this sound is near the $C_3 = 16\frac{1}{2}$ vibrations, the lowest tone which the ear is capable of distinguishing as such.

FIG. 70.

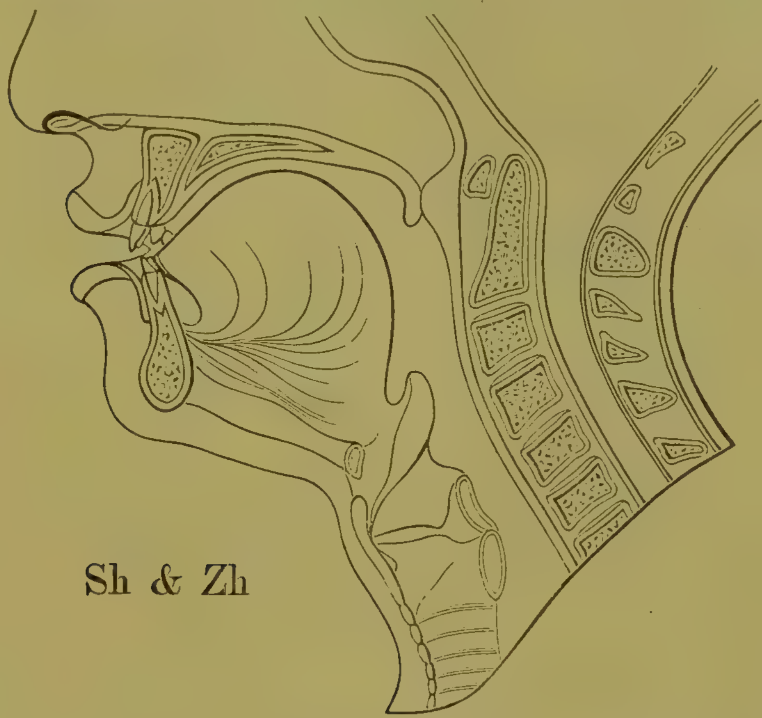


The "lingual *r*," on the other hand, is produced by the tip of the tongue being brought close to the anterior portion of the palate, without, however, quite touching it, while its edges are applied against the alveolar borders of the upper jaw (Figs. 69 and 70). Thus a gutter is formed, as in some of the foregoing consonant sounds, and the air-current, being directed against the tip of the tongue, throws it into slow vibrations, whereby the "rolling" sound of the "lingual *r*" is produced. The pitch of the proper tone of this consonant is nearly to $C_2 =$ 33 vibrations; *i. e.* one octave higher than the "guttural *r*."

2. *The Compound Self-sounding Consonants.*—This class comprises the consonants which really are a combination of two of the sounds belonging to the first class, and in the English language but two sounds are comprised in it—viz. the *Sh* and the *X*.

In the *Sh* two obstructions are produced in the oral cavity, through which the air-current has to pass. The one is produced by the tongue being almost in contact with the middle of the palate, as in the *J* sound, while its edges are firmly pressed against the alveolar borders of the

Fig. 71.



upper jaw; and the other by the teeth being brought closely together, leaving but a narrow slit between them, as in the *S* (Figs. 71 and 72). In this way the two compound sounds are merged into one, modifying each other so as to result in the "rushing" sound of the *Sh*. On account of the combination of these two sounds there are noticed two proper tones in this sound, the one produced by the vibration of the air contained in the cavity of the mouth, and the other by the vibration of the edges of the teeth. To a trained ear a third tone is also appreciable, which is the so-called "resultant" tone produced by the combination of the two first tones.[1] The pitch of the first of these tones is nearest the $d^4 = 2328$ vibrations; of the second, nearest the $b\flat^4 = 3666$; and of the resultant tone, nearest the $f^3 = 1378$ vibrations.

Fig. 72.

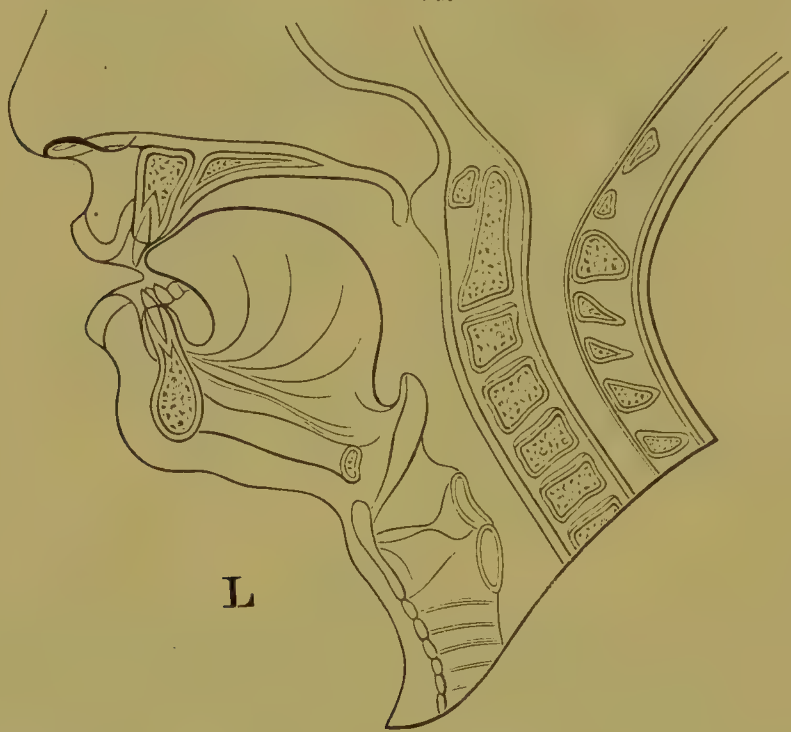
The *X* is a combination of the *S* and the *K* sounds, and is formed like these, the tongue pressing against the velum palati with its back, forming the gutter with its

[1] An explanation of the combination and resultant tones would lead us too far into the science of acoustics, and the reader is referred to any of the textbooks on physic for a detailed description of this phenomenon.

middle, and directing the air-current through the narrow slit between the teeth (Figs. 56, 57, 63, and 64). The proper tones also are double, as in the *Sh* sound, but a resultant tone cannot be heard. Their pitch is that of the *K* nearest the $c\flat^2 = 614\frac{1}{2}$, and that of the *S*, nearest the $c\flat^4 = 3666$ vibrations.

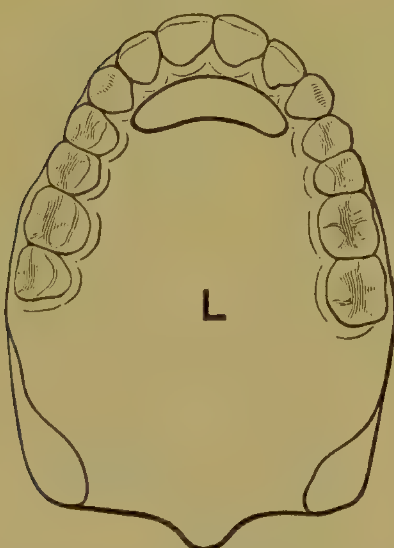
3. *The Simple Tone-borrowing Consonants.*—The consonants belonging to this class can be heard only in connection with a vowel, and because

FIG. 73.



in their formation an obstruction to the outflowing air-current does not take place and the breath is emitted noiselessly and without effort. For this reason also no proper tone, the pitch of which could be determined, is heard.

FIG. 74.

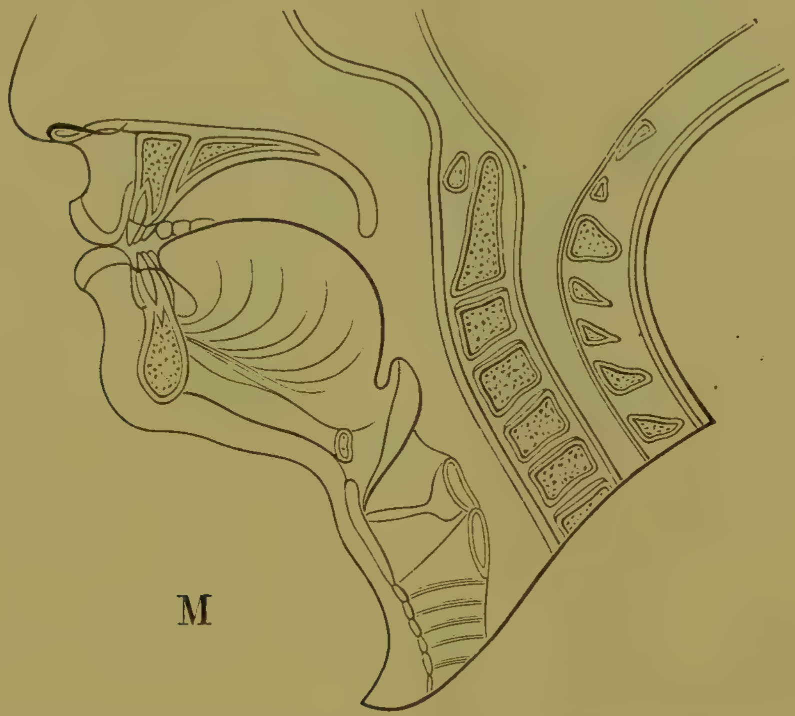


The first of these consonants is the *H*, an aspirate, which in some languages is not even accorded a place among the letters of the alphabet, but is designated by a sign; as, for instance, in the Greek. This consonant consists in the somewhat forcible exhalation of the breath through the perfectly unobstructed oral cavity, which assumes the shape of the vowel in connection with which the *H* is pronounced, or if whispered the cavity has the shape which it assumes in the formation of the vowel *Ah* (Fig. 45). The posterior nasal orifice is of course closed to allow the air to flow through the mouth.

The *L* is formed by the tip of the tongue being placed against the anterior portion of the palate and the internal

surface of the upper incisor teeth, while its edges lie flat within the body or the floor of the mouth. The teeth and lips are parted and the velum

FIG. 75.



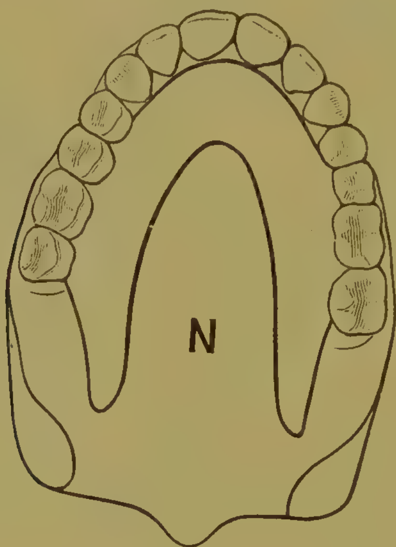
palati applied to the pharyngeal wall (Figs. 73 and 74). This arrangement allows the breath to flow gently through the two large openings

FIG. 76.

left between the edges of the tongue and the upper teeth on either side of its tip. In the whispered *L* no proper tone is heard, but as soon as

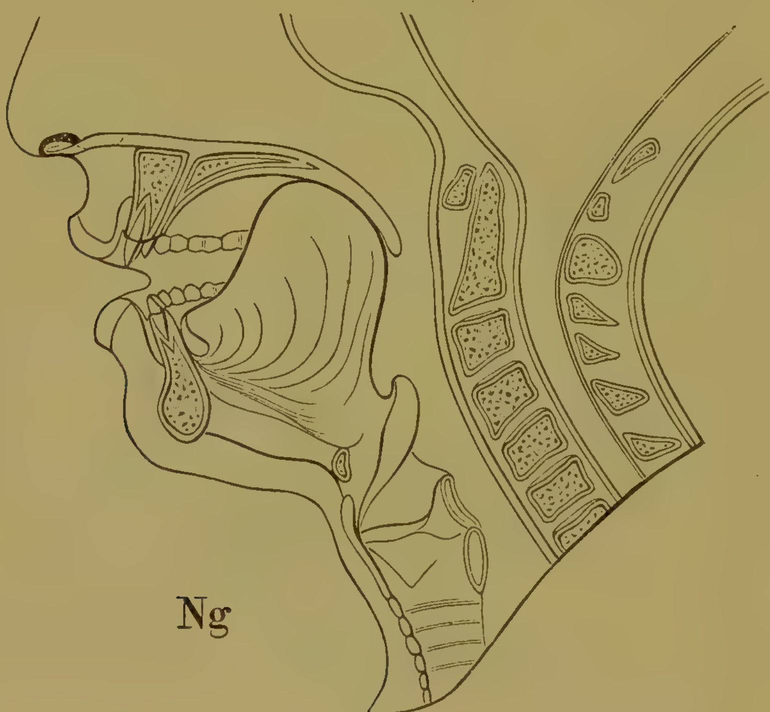
a vowel is sounded after it, a tone is heard which comes close to that of the vowel *E*, and for this reason the *L* is considered in some languages as a semi-vowel, and is frequently interchanged with the *E* sound in the Romanic languages; as, for instance, in the Latin word *flos*, which is changed into *fiore* in Italian.

Fig. 77.



In the *M* the organs of articulation are in a position of absolute rest; that is, the tongue, lips, teeth, and velum are in the position which they

Fig. 78.



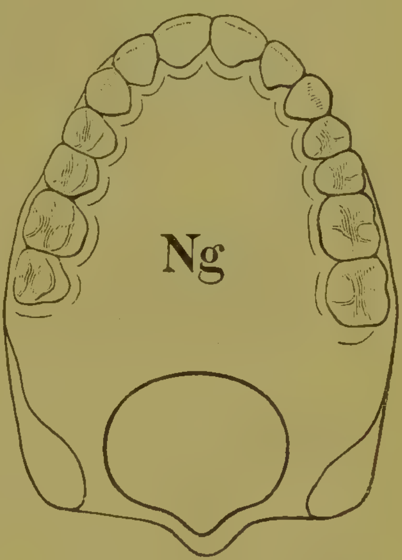
assume in ordinary breathing through the nose (Fig. 75). In consequence no sound is heard when it is attempted to whisper; the consonant and its characteristics are only brought out when a vowel sound

accompanies it; and even then the vowel sound must be made with the lips closed and the posterior nasal orifice opened, letting the sound escape through the nose before or after the vowel itself is pronounced, according to the position of the *M* either before or after the vowel.

The formation of the *N* is in all respects but one identical with that of the *M*, and the difference between the two consonants consists in the fact that in the *M* the oral cavity is closed by pressing the lips together, while in the *N* the closure is made by the tip and edges of the tongue being applied to the alveolar border of the entire upper dental arch and the enlarged area of the palate (Figs. 76 and 77).

4. *The Compound Tone-borrowing Consonants.*—This last class of consonants contains but two sounds, the *Ng* and *W*, which are in reality combinations of two consonants. Thus, the *Ng* is a combination of the *N* and the *G*, inasmuch as the oral cavity is closed by the back of the tongue being applied to the velum palati, as in the *G*; and the air is allowed to escape through the nose, as in the *N*, the posterior nasal orifice being left open for that purpose. As in the *N*, no sound, except perhaps the forcible expiration through the nostrils, is heard when the *Ng* is whispered, and it can only assert itself in connection with a vowel (Figs. 78 and 79).

FIG. 79.



The same is true of the *W*, which is a combination of the *H* and the *V*, and differs in its formation from the *H* only in the lips being brought closer together and allowing the breath to escape through a slit-like opening between them. As in the *H*, the nasal cavity is separated from the rest of the resonant cavity by the velum palati being again pressed against the ridge formed by the constrictor of the pharynx.

Pathology of Speech.

Having described the mechanism of articulate speech more or less in detail, it remains to close this article with a short review of the causes which give rise to defective speech. It is, however, necessary, in order to appreciate the defects of speech as they are noticed in various individuals, and to come to a correct conclusion regarding their cause, to have a clear understanding of what is meant by *language*, *dialect*, and *accent*, and a definition of these terms is therefore given.

Language, as used by man, is the arbitrary but constant sequence of articulate sounds, forming what are termed words, and expressing as such simple ideas, and the arbitrary but constant sequence of words termed sentences, expressing compound ideas. The difference between different languages consists in the fact that the same simple idea is expressed by different but constant combinations of articulate sounds, and that the compound ideas are expressed by different but constant

sequences of words. In languages which are related to each other a similarity both in the words and sentences can be observed, but in those not so related a great dissimilarity in words and sentences exists.

Dialect is the substitution of other articulate sounds for those which are correct in the language, without, however, entirely destroying the characteristic sound of the word expressing the simple idea, and the introduction into the sentences of words foreign to it, or of a change in the sequence of the words of the sentence without destroying its characteristics. Thus, a dialect is only a variety of the language, and is limited to people living in a particular locality or who belong to different nationalities or races, all, however, speaking the same language.

Accent, by which is understood the peculiarity of speech characterizing foreigners speaking a language different from their mother tongue, and which is perceptible even if the language is spoken correctly in regard to pronunciation, grammar, syntax, and even colloquialisms, consists in the peculiar inflection of the voice in speaking, or, as it may be expressed, in the peculiar melody of speech. Every language possesses this characteristic melody, which is independent of the accentuation of the individual words and of the inflection of the voice demanded by the sense of the sentence; and so definite is this that a language can be recognized even if the speakers are too far removed from the listener for the latter to hear and recognize the individual words and sentences. And, further, we find a great similarity in the melody of the languages which are related to each other, so that it is difficult to distinguish German from Swedish and Italian from Spanish without hearing and understanding the individual words, while there is no difficulty in appreciating the difference between English and French, even if the listener should not know anything of either language. This melody of the languages becomes so impressed upon the mind when a language is acquired in childhood and spoken for years that the impression is never entirely erased, and is transferred to any new language which may be acquired in later years. As the pronunciation and composition of a language are altered by different localities or nations or races, so also is this melody slightly changed in the same manner, without, however, losing its general character; and thus we find that in English there are different accents, such as the Southern, the New England, the English, the Scotch, and so-forth.

The defects of articulate speech, which we are now prepared to consider, must be divided into two classes, according to their causation—viz. into those which are of mental origin, such as lisping and stammering, and those which are caused by physical defects in the organs of speech. The first class need not be here considered in detail, as an exhaustive description would carry us too far; therefore it is sufficient to say that—

Lisping occurs when the person speaking puts the tip of the tongue between the edges of the incisor teeth, just as for the formation of the *Th* sound when the *S* sound is to be pronounced. This is a habit, and can easily be overcome by the person himself if he will devote a little time and trouble to teach himself the correct pronunciation of the *S* sound.

Stammering, on the other hand, consists in a want of proper co-ordination of the muscles of respiration and those moving the different parts of the oral cavity, and in rare cases those moving the vocal cords (in the so-called laryngeal stammering). In other words, the stammerer does not interrupt the outflowing air-current at the proper time and with the proper amount of force in the formation of the consonant sounds, and, being conscious of the defect, repeats the movement with like result until either he happens to hit the proper time and goes on with the rest of the word, or until he is exhausted by his ineffectual efforts. It is, however, a curious fact that the stammerer can generally *sing* the words without difficulty; which finds an explanation in the difference between ordinary articulate speech and song with words. This difference is simply that in ordinary speech the articulate sounds predominate over the vocal tones, while the reverse is the case in song with words, in which the musical vocal tones are predominant, while the articulate sounds are slighted. Thus, it becomes impossible to speak and sing well at the same time, and the so-called *recitative* in opera is a compromise in order to carry on the action of the libretto. Stammering, like lisping, can be cured by careful attention to the proper formation of the consonant sounds and the careful avoidance of the use of more breath than is necessary; but it takes much time and labor to overcome the difficulty.

The defects due to physical causes are very numerous, but can, by adhering to the classification of articulate sounds adopted in this article, be described in a few words.

As has already been shown, any defect in the larynx interfering with the vibration of the vocal cords will materially alter the voice, and therefore either change or altogether extinguish the vowel sounds. The same is true, but in a less degree, when obstructions exist in the resonant cavities above the larynx, such as enlarged tonsils, enlarged pharyngeal tonsil, obstruction of the nasal cavity by tumors, or hypertrophies of the turbinated tissue. As a rule, however, the parts become accustomed to the presence of these obstructions, and by a slight change of their relative position still tune the cavity to the proper pitch of the vowel, so that the vowel sounds are but slightly affected or changed in character. It is different with the consonant sounds, which are greatly changed, or even made impossible, by but seemingly slight alterations in the resonant cavity.

Thus, among the simple self-sounding consonants we find that cleft palate or loss or paralysis of the velum palati, or even only a comparatively small perforation of its body, will allow the air to pass through the nasal cavities and prevent to a greater or less extent the formation of all the sounds of this class. The lingual *r* sound is impossible when the frænum of the tongue is too short to allow the tip of the tongue to reach the roof of the mouth. This is commonly termed "tongue-tied," and is readily relieved by cutting the frænum. Loss of the upper incisors entails the loss of the consonant sounds of *Th* and *S*, while the *T* and *F* sounds are greatly interfered with. Enlarged tonsils prevent the proper formation of the "guttural *r*" and of the *K* and *J* sounds by preventing the back of the tongue applying itself to the pal-

ate. The compound tone-borrowing consonant sounds of *Sh* and *X* are interfered with by the causes described above, making the formation of the *S* and *K* sounds difficult or impossible.

The simple tone-borrowing consonants, with the exception of the *H* and *L*, are all interfered with by obstruction of the nasal cavities, and in fact the inability to pronounce these consonant sounds at once points to a defect in that region of the resonant cavity. There is a slight difference in the attempted sound of these consonants according to the location of the obstruction, whether far back and caused by an enlarged pharyngeal tonsil or tumor or hypertrophy in the naso-pharyngeal space, or whether it is situated in the anterior nasal chambers and caused by deflection of the septum anterior, hypertrophies, or polypi. The *L* sound may be made impossible, like the lingual *r*, by too short a frænum of the tongue.

Among the compound tone-borrowing consonants the *Ng* sound is impossible where nasal obstruction is present or where the faucial tonsils are very much enlarged, while the *W* sound is interfered with when the nasal cavity is not tightly closed posteriorly by the velum palati.

As a matter of course, defective dentures and deformities in the dental arch or palate will affect articulate speech to a greater or less extent; but, as has already been hinted, the different parts of the organs of articulate speech will adapt themselves to changes, and make up for defects in such a manner that the articulate sounds are still recognizable, although not formed in the usual manner. Thus, there are a number of cases on record in which after partial and even complete excision of the tongue intelligible articulate speech was still possible.

The allotted space does not permit a more detailed description of the various defects of speech and their individual causes, and this summary review must therefore suffice for this article.

PART III.

ASSOCIATE DENTAL AND ORAL PATHOLOGY, AND ORAL SURGERY.

DISEASES INCIDENT TO THE FIRST DENTITION.

By JAMES W. WHITE, M. D., D. D. S.

The term "dentition," as here employed, does not include the development of the teeth-germs, but refers simply to the natural processes (usually beginning between the fifth and eighth months and terminating between the twenty-fourth and thirtieth months) by which the teeth are liberated from their osseous and fibrous coverings and made subservient to speech and mastication. "Incident" in the title of this article is to be understood as indicating various local and systemic disturbances which, occurring simultaneously with the eruptive processes of dentition, are in some instances at least certainly dependent upon them.

The first dentition is a physiological and anatomical crisis of infancy—a process which, under conditions in every respect favorable, may proceed with little or no disturbance to the child, without attracting the attention of even a watchful mother, though it is rare for a child to pass through the period of dentition without more or less manifestation of suffering, and frequently there are serious and alarming disturbances of its health.

Authorities are at variance with regard to the liability to, and the frequency and importance of, departures from physiological dental evolution. There are extremists who over-estimate the average influence of teething as a disturbing element, and on the other hand there are those who underrate the difficulties which may attend it. It is not disputed, however, that it is during the teething period that the greatest number of deaths occur. The mortality of infancy is alarmingly great, and though it must be admitted that many infantile diseases are in no way related to dental evolution, yet it is reasonable to assume that it has a large share in the production or aggravation of the derangements of health so common and so serious at this time of life, and that vast numbers of children die because of lesions which, if not dependent on, are concomitant with, the process of dentition. The nervous perturbation occasioned by the eruption of the teeth increases the susceptibility and lessens the resistive power of the child. Thus, because of a disturbance of its equilibrium, it is not only more sensitive to the ordinary causes of derangement—to the impression of cold or to the irritation from unsuitable food—but it is also less capable of combating disease; and a catarrhal attack, an indigestion, or an eruptive fever, coming at

this time, acts upon a system less able than usual to resist injurious influences.

The period during which the teeth and surrounding tissues are undergoing those changes which precede and accompany the eruption of the former being one of augmented nervo-vascular action, there is then a more than usual liability to disturbance of harmony, and consequently a predisposition to functional derangement. It is analogous in this respect to other so-called critical periods, such as utero-gestation or the establishment and cessation of the menstrual function, which, though purely physiological processes, are subject to deflections which not infrequently place them within the domain of pathology. At each of these periods, but especially during the eruption of the teeth, the brain and nervous system, the stomach and intestinal tract, the circulatory and respiratory systems, show an increased though varying liability to irritation.

Coincident with the development of the masticatory apparatus other important changes are taking place in the organization of the child, notably in the stomach and intestinal tract, preparing these for the reception and digestion of solid food. These concurrent changes, while exercising their full share in the production of constitutional disturbances at this period, increase also the nervous impressibility of the child, and thus lessen its ability to resist other perturbative influences. The natural vigor of the child, the state of its general health, and the conditions by which it is surrounded exert an influence in preventing or promoting aberrations in dental evolution. Improper clothing, atmospheric variations, intense or prolonged heat, cold or dampness, miasmata, the exanthemata, indigestion, excitement of the nervous system by fright or anger—anything which, causing a modification in the normal standard of healthy life, reduces the resisting power of the organism, may find pronounced expression in a disturbance of the otherwise physiological process of dentition.

A consideration of pathological dentition recognizes interference with function in contiguous or remote organs from causes originating in the mouth, and, as well, the expression in the oral cavity of constitutional disturbance. Pathological dentition may thus be credited with causing or aggravating various systemic disorders, as such disorders may in turn be reasonably suspected of interference with this developmental process. Therefore, while dentition is not to be held accountable for all the ills to which infancy is heir, it is unsafe to ignore the possible pathological complications in any case. It does not militate against the theory that dentition is frequently a disturbing element because multitudes of children escape, in part or altogether, the evils with which others, having feebler powers of resistance, are afflicted. There are varying degrees of susceptibility, differences of environment, of hygienic care, of quality of food, of clothing, and of habits taught or allowed, that enter into the problem of the maintenance of infantile health, the influence of which can be only approximately estimated. Viewing dentition, therefore, either as the principal factor in the production of constitutional disturbance or as a single link in a chain of deranged activities, it is surely desirable that a careful investigation should be

made as to the condition of the eruptive process in all cases of infantile disease.

An intelligent understanding of the subject under consideration requires an appreciation of the physiological relations of the mouth and of the peculiar sensitiveness of infancy. Anatomically considered, no other portion of the human organism offers such a complex association of tissues as those which compose the mouth; no other has such diversified physiological functions, and, from a pathological standpoint, no such significant systemic relations. Its various offices necessitate a no less varied organization and an equally varied relation with other structures. The wide circle of its anatomical and physiological sympathies suggests an equal circle of pathological complications, and indicates the diversity, as well as the gravity, of the disturbances dependent upon systemic relations to which its lesions may give rise. By means of its lining mucous membrane the mouth is related by continuity with the pharynx, œsophagus, stomach, and intestinal tract, the larynx, trachea, and bronchi, and by contiguity, as well as by continuity, with the eyes, ears, nares, and antra. But it is to direct or sympathetic nervous relations that the most formidable disturbances resulting from an interference with the eruptive process are to be attributed. The terminal distribution in and about the mouth of the sensory and motor branches of the sensitive trigeminus, its extensive topographical connections and their relations to the heterogeneous tissues and manifold functions concerned, and its association with the great sympathetic, thus connecting the teeth with the entire organism, explain the liability to aberrations of sensation, nutrition, and motion when its termini are the seat of disordered sensibility. It should be remembered that the fifth nerve is the largest of the cranial nerves; that it is the great sensitive nerve of the head and face, the nerve of the special sense of taste, the nutrient nerve of the teeth, and the motor nerve of the muscles of mastication; that it not only gives off branches—the ophthalmic, the superior and the inferior maxillary—but that these, by subdivisions, supply branches to the eye and eyelids, the nose, the ears, the forehead and scalp, the upper and lower lips, the chin, the gums, the tongue, and the teeth of the upper and lower jaws; that filaments of the maxillary branches again join the ophthalmic branch and the seventh nerve, which controls the muscles of the face; that its numerous ganglia, its varied functions, and its frequent communication with the sympathetic nervous system give it unequalled importance among the cranial nerves. It is evident from this standpoint that the pathological bearings of deranged action connected with the teeth may not be easily defined or limited.

In reflex action is found an explanation of the mutual relations of apparently unconnected disturbances. The influence of a pathological condition, acting as an irritant upon an afferent nerve, is conveyed to a related nerve-centre which may from some cause be in a state of exalted sensibility, and is thence reflected along an efferent nerve, producing reflex phenomena. Reflex disturbances are variable in character, and their mechanism is not always explainable. But as efferent nerves are distributed to glands and to muscles, voluntary and involuntary, reflex phenomena generally occur in one of two principal directions—viz. in

modified secretion or muscular spasm. There may be either an increase or a diminution in the amount of secretion in the affected gland. Irritation of an abdominal nerve may lead to a suppression of the renal secretion. A mental impression, as fear or anxiety, generally produces increased renal and intestinal secretions, but arrests the salivary secretion. In the adult, reflex spasms are common, from various causes, in the stomach, at the neck of the bladder, in the urethra, in the sphincters of the vagina and rectum, in the œsophagus, larynx, bronchi, intestinal canal, ureters, and gall-duct, and notably in the uterus. Reflex muscular spasms may also originate through the agency of vaso-motor nerves acting upon the contractile walls of blood-vessels, causing either contraction or dilatation. Examples of such effects are the pallor produced by fright and the suffusion of the face and neck in blushing.

Owing to the predominance of the spinal system in infancy this sympathy of distant organs with one another is notably greater than in adult life, creating a special tendency to the production of reflex phenomena. The exceeding mobility of the nervous system at this period is also such that a mere peripheral irritation is liable to result in sympathetic general disturbance—often, indeed, to the overshadowing of the original lesion by accessory phenomena. The profound disturbance which may be excited in an infant by even a slight functional disorder is a matter of common observation. A little irritation of the larynx will produce spasmodic croup, a little indigestible food may cause convulsions, and almost any excitant may provoke vomiting. Thus a mere interference with function may result in consequences out of all seeming proportion to the gravity of the cause. Post-mortem examinations of infants are therefore very frequently unsatisfactory, because they fail to afford any explanation in structural change of the cause of death. There is, however, in infancy, not only a predisposition to disease, owing to the weakness of the organization, but a tendency of functional derangements to excite organic changes, and thus to add new complications.

The body of an infant is not a miniature of an adult organism, but is characterized by peculiarities of structure and function. All of its organs are incompletely developed, but not uniformly so. The brain is, proportionately to size and weight, larger than in the adult, imperfect in structure, and so soft as to be almost a semi-fluid. The brain and its meninges are extremely vascular. The tissues generally are softer, more vascular, and more distended with fluids. The skeleton is for the most part cartilaginous, the muscles are gelatinous, the cellular tissues are filled with serum, and the skin is vascular and sensitive. The abdomen is disproportionately large; the mucous membrane of the alimentary tract is soft, vascular, and hypersensitive. The mesenteric and salivary glands, the pancreas and lacteal vessels, the kidneys, supra-renal capsules, and liver, are relatively larger than in the adult. The structure of the spinal cord and nerves is more perfect than that of the brain, and therefore the functions of sensation and voluntary motion are correspondingly in advance of the functions directly dependent on the cranial nerves. The glandular, lymphatic, and capillary systems, and the nutritive system generally, are the most fully developed, and functional activity is confined chiefly to the nutritive processes. These

structural and functional peculiarities explain the tendency of disease in infants to assume an inflammatory type, and also explain the facility with which morbid action is transferred by extension, metastasis, or reflection to organs not originally implicated. The liability of an irritation or inflammation of the mucous membrane of the alimentary tract to set up an analogous condition in the brain or its meninges is a familiar example of this, as is also the tendency of a morbid action in a mucous membrane to extend throughout the entire length of the affected tissue. Thus, an inflammation of the tonsils may invade the pharynx and œsophagus, the larynx and trachea—may even follow the gastro-intestinal mucous membrane and involve the mesenteric glands. The activity of the vascular system, the free supply of blood to the tissues, the liability to effusion of serum or lymph, and the susceptibility of the nervous system, contribute to the creation of a special tendency to intense and dangerous reactions from local irritations. The balance between health and disease in an infant is delicately adjusted, and slight disturbing causes will incline it to one or the other side.

The evolution or development of the teeth commences about the seventh week of fœtal life, and is continued within the jaws until (generally between the fifth and seventh months after birth) the eruption or cutting of the teeth begins—a double process, consisting of the gradual elongation and rising of the teeth and the coincident absorption of the hard and soft tissues overlying them. The alveolar borders are the first to show signs of the absorptive process by a dissolution or melting of their approximated edges. The teeth, rising in their sockets, the roots meanwhile lengthening, press upon the overlying gums, which, becoming thinner and thinner, finally allow them to escape. It is therefore the removal of impeding tissue by absorption which permits the passage of the teeth through the gums.

Normal dentition depends upon an absolute accord between the processes of growth and absorption, as well of the crypt as of the mucous membrane covering the tooth. When, therefore, from any cause, there is a want of such accordance the propulsive and resistive forces are in antagonism, and irritation is the result. If the eruption proceeds physiologically, the absorption of the overlying tissues is effected without the production of irritation, but an abnormal pressure arrests the absorptive process and produces congestion, tumefaction, induration, and ulceration. Thus, if the advance of the tooth is more rapid than the removal by absorption of the superimposed tissues, these act as a mechanical obstacle, and the tooth becomes in turn a mechanical irritant.

It has been urged that dentition cannot produce special discomfort, because of the comparative insensibility of the gum-tissue, and because the progressive growth of a tooth is inadequate to make sufficient pressure to cause serious distress. But this argument finds answer in tumid, tense, and shining gums; in ulceration, in sloughs, and in the black, thickened blood which sometimes follows a touch of the lancet. It is true that normal gum-tissue is comparatively insensitive, but when inflamed it becomes exquisitely tender. The usual results of continued irritation of any tissue follow—determination of blood, congestion, effu-

sion, and even suppuration. (It is in such cases that "scoring"—superficial incisions—of the gums may afford an incomplete relief by lessening the capillary distension.) Under such circumstances the gums are so sensitive that the lightest touch will cause pain, so that the child on attempting to take the breast will jerk back its head—a manœuvre which is frequently mistaken as an evidence of colic; but a little attention enables the nurse to distinguish the difference between the indications of the two troubles.

Many who admit that dentition may exercise an influence on the etiology of the diseases of infancy assume that the explanation of deranged action is to be found only in the direct pressure of the advancing tooth upon the fibrous tissue, which fact is always to be determined by local signs. It is doubtless true that there is generally some such external evidence, but it does not follow, because there is no local manifestation, that therefore dental evolution can have no relation to a pathological condition. Hyperæmia of the gums is perhaps generally caused by the eruption of the teeth proceeding more rapidly than the absorption of their integumental covering, and the undue pressure thus exerted may occasion trouble by the irritation of the nerves of the gum-tissue, manifested locally by soreness, tumefaction, redness, or ulceration; systemically, by irritability, sleeplessness, fever, etc.

But the direct pressure of the advancing tooth upon the fibrous integuments is not the only nor the principal factor in disturbance of equilibrium in pathological dentition. The most serious complications are, it is reasonable to suppose, caused by the resistance of the gums, and consequent pressure upon the nervous and vascular supply of the pulp, giving rise to severe and unremitting pain—a true toothache, comparable only to that exquisite torture which is experienced in after-life from an exposed and irritated pulp. The condition when a tooth is thus situated is not unlike that which is found in whitlow—vascular and sensitive tissues bound down by unyielding coverings. If such a perversion of this physiological process is possible, there can be no question as to the extent of the mischief which may result—an irritability of the general system which finds expression in loss of appetite, sleeplessness, nausea, thirst, fever, diarrhœa or constipation, convulsions, paralysis, and other serious lesions; many of which, as strabismus or epilepsy, remain throughout life.

It is not surprising that those who hold the theory generally assumed and taught, that the direct pressure of the advancing tooth upon the fibrous tissue is the explanation of all symptoms attributable to pathological dentition, should underrate the distress and danger which may occur. But the severity of the disturbance frequently witnessed suggests a more serious complication, and a consideration of the conditions justifies a graver diagnosis. It must be remembered that at the period of eruption the roots of the teeth are yet incomplete. Instead of the conical termination and minute foramen which characterize a perfected tooth, the aperture is nearly as large as the root itself, and thus when the sensitive pulp, made up of connective tissue, blood-vessels, and nerves, is in a condition of irritation because of the morbid activity of the process of dentition—augmented vascular and nervous action—there may be

produced a hyperæmia sufficient, possibly, to cause the protrusion of a part of the mass from the incomplete aperture of the root, giving abundant cause for extreme constitutional disturbance. If in the adult the irritation of a dental nerve may give rise to otalgia, otorrhœa, deafness, amaurosis, hemicrania, neuralgia, hysteria, chorea, epilepsy, tetanus, etc., it is surely not only possible, but highly probable, that a like irritation may be the occasion of grave and even fatal disorders in the infant.

That this resistance of the gum-tissue is the occasion of the constitutional disturbance so often seen in teething children appears probable in view of those cases in which, though there be no local indication of trouble, every untoward symptom disappears promptly after lancing of the gums over the tooth or teeth next in order of eruption. It is almost demonstrated, negatively, by the inefficiency of hygienic measures and of systemic medication, by failure to procure relief by scoring the gums (a practice which has brought the lancet into undeserved disrepute), and positively by the immediate, apparent, almost magical, improvement which follows the removal of the cause—viz. the pressure of the fibrous tissue upon the advancing tooth and its nervous supply. This theory makes it easy to understand how the thorough lancing of the gums over the tooth or teeth thus situated may give a relief so immediate and complete that there shall be no room for doubt as to the correctness of the diagnosis.

If these views be correct, it is evident that there may be cases in which a train of morbid symptoms presents, ending possibly in convulsions and death, without the existence of a single local indication. It is not, therefore, a sufficient reason for not lancing the gums that they exhibit neither tumefaction, redness, induration, nor the whiteness of the presenting tooth, though generally there is some external local manifestation. If, however, there be no obvious explanation for the occurrence of untoward symptoms during the period of dentition, it seems the part of wisdom to give the child the benefit of the doubt by free incisions over the tooth whose eruption is, in accordance with general laws, to be anticipated, even though there be no hyperæmia of the gums; especially as the operation causes only a trifling amount of pain, inflicts no injury, and is practically free from danger. Local indications demand the lancet; constitutional symptoms of distress not otherwise accounted for suggest and justify it.

The manifestation of functional inharmony from pathological dentition will depend, as in trouble arising from any other disturbing cause, upon the temperament and health of the child, its dietetic management, and its hygienic surroundings. In some cases there is a gradual development of biliary, gastric, enteric, and cerebral complications; a slow but steady loss of vital power, with no effort at recuperation, and feeble resistance to the undermining influences which gradually but surely wear out the young life. In other cases the indications of disturbance of function are manifested primarily in the nervous system; the symptoms are all characteristic of acute derangement, and are dangerous from their violence and uncontrollability. High fever, vomiting, choleraic diarrhœa, meningitis, convulsions, stupor, and death are

the rapidly-succeeding phenomena. Between these two phases, chronic and acute, there is every conceivable grade of symptoms, every imaginable complication. Many disorders occurring during dentition are not incident to, but coincident with, this process, and it frequently requires a nice discrimination to determine the rôle of the teething process in the causation of morbid manifestations at this period.

Usually, the first indication of the advance of the teeth is an increased flow of saliva—a healthy manifestation, as it serves to keep the mouth moist and cool. This increased flow of saliva, called "drooling," is doubtless due to the irritation of the trifacial nerve, which is sensory to the teeth and nutrient to the salivary glands. As the itching or discomfort increases, the child is observed to be disposed to carry its fingers or anything which it may have in its hands to the mouth, as though a sense of slight irritation were relieved by rubbing or pressure, and an evident satisfaction is experienced by the child if the gums are rubbed gently by the nurse. If the discomfort becomes more pronounced, the mouth is likely to be hot and dry, and more or less febrile excitement is manifested. Frequently a diarrhœa ensues, which, if not too severe or protracted, is beneficial rather than hurtful—requiring care, however, that it does not itself become a source of danger. An unusual redness of one or both cheeks, sometimes changing from one to the other, is a frequent symptom of nervous disturbance. Eruptions are apt to appear—usually on the cheeks, but sometimes on the head or even over the whole body—or ulcerations on the tongue, lips, gums, and inside of the cheeks. Itching of the nose, twitching of the muscles, dilatation of the pupils, fretfulness, restless sleep or wakefulness, thirst, and loss of appetite, are evidences of increasing irritation. A swelling of the cheek, with more or less redness, may result from a congestion of the gum over an erupting tooth, implicating also the cellular tissue. If the eruption of the tooth is still delayed, the child becomes more uneasy, troublesome, peevish, cross, and even vindictive; cries when awake or stops crying only to scream; moans when asleep; thrusts its thumb or finger between its jaws; refuses to be amused, and treats the effort as an indignity; throws down its toys when handed to it as though in a passion, and is outraged by any attempt at diversion; compresses its lips; corrugates its brow; shows an intolerance of light; pulls at its hair or ears; attempts to slap or scratch its nurse; refuses its food, or vomits it if swallowed. Associated with these indications, some or all, or quickly succeeding them, are persistent nausea and diarrhœa, fever, thirst, convulsions, or other systemic complications.

If the theory be correct that in such cases the trouble is mechanical and local, it would appear to be a folly to seek relief for the child by general medication, by relaxants, derivatives, calmatives, febrifuges, local emollients, fomentations, anodynes, etc. before the local and mechanical requirements had received the proper attention; though of course the judicious treatment of pathological dentition should in all cases include special hygienic care and medication if required, with the view of securing a perfect equilibrium of all the functions.

A familiarity with dental evolution is necessary to a proper appreciation of the probabilities in a given case; for although there is not

absolute uniformity in the order of eruption, the normal sequence will afford a basis for approximately correct interference. The period and order of eruption of the deciduous teeth are among the elementary facts with which every practitioner—indeed, every parent—should be familiar. The rule is that the lower teeth precede the upper of the same class by two or three months, but not infrequently the upper precede the lower by the same difference in time. Again, the rule is that the teeth are erupted in pairs, with an interval between the different pairs, but occasionally two or three pairs erupt concurrently. Still again, the rule is that the amount of irritation holds a relation to the number of teeth advancing simultaneously, but owing to varying susceptibility a single tooth may cause more disturbance in one case than a half dozen will in another. The usual order of eruption is as follows, the lower preceding the upper: Central incisors, fifth to eighth month; lateral incisors, seventh to tenth month; first molars, twelfth to sixteenth month; cuspids, fourteenth to twentieth month; second molars, twentieth to thirtieth month. There is occasionally great deviation from regular order as well as from usual time in the eruptive process. Anomalous cases are those in which one or more teeth are found erupted at birth, and those in which no teeth appear until long after the usual period—as sometimes happens, not until the second or even the third year. Premature dentition is more apt than a tardy eruption to be attended by constitutional disturbances—precocity being an evidence of weakness rather than of strength, not alone in the child, but in the character of the denture. It is also worthy of note that when the eruption of all of the teeth is delayed, the process, when once begun, is likely to be rapidly completed, and generally with but little disturbance to health. Exceptions to this rule are cases in which late dentition is associated with tardy and imperfect development of the body generally, because of feeble vitality or constitutional disease.

If the positions assumed as to the etiology of the morbid phenomena connected with dentition be correct, it follows that the lancing of the gums over the erupting tooth is the procedure which should be promptly resorted to as that most essential and most likely to afford quick relief, unless, indeed, it can be shown that there are valid objections to the operation.

The objection most frequently urged is that unless the tooth is erupted before there is time for the wound to heal, a cicatricial tissue is formed which offers increased resistance. This argument is in contravention of recognized facts as to the reparative process. Cicatricial tissue is always of a lower degree of organization than the original structure, and consequently easier of absorption. The uniting medium in the repair of a solution of continuity possesses less vitality, is less perfectly nourished, and is easier of disintegration than the original tissue. The tendency of scar-tissue to break down is a matter of common observation even among the laity, and except in the case of gum-lancing is not disputed by any medical authority. Gum-tissue offers no exception to the general rule.

The possibility of serious hemorrhage following the operation is sometimes urged as an objection, but the argument applies with equal force

not only to every surgical operation, but to all medication. If every possible fatality resulting from idiosyncrasy or unexpected complications is to be considered as contraindicating medical or surgical interference, the sphere of the surgeon and physician will be notably narrowed. Granting that it is among the possibilities that a child may die from hemorrhage following the lancing of the gums, it must also be admitted that occasionally an adult dies from hemorrhage following tooth-extraction; but, except in cases of known hemorrhagic diathesis, this liability is never taken into account. A suggestion of such diathesis or of hereditary probabilities it would of course be well to heed. In such cases the administration of the tincture of iron and of erigeron or ergot for a few days previous to lancing would lessen the liability to hemorrhage. The cases in which any serious trouble has resulted from hemorrhage following the lancing of the gums must be very rare, and it seems improbable that even a threatening hemorrhage could not be controlled by judicious treatment.

A further argument against lancing is based on the occasional necessity for a frequent repetition of the operation; but the reasoning applies with equal force to any medication which fails to secure permanent relief in a given derangement likely in the nature of things or under special circumstances to demand a repetition.

The possibility of injury to the developing tooth is an objection not infrequently made to the use of the gum-lancet, but only an ignorance of the anatomy of the mouth inexcusable in any dentist or physician could lead to the infliction of permanent injury. The probability of complication in erysipelatous or diphtheritic conditions is of course admitted, and such manifestations should be regarded as contraindicating the operation.

In addition to the objections noted the suggestion of lancing the gums meets frequently strong opposition on the part of mothers, because of their dread of the infliction of suffering upon tender babes. But that the amount of pain caused is of the most trifling character may be inferred from the readiness with which a child old enough to appreciate conditions submits to the operation after it has once realized its benefits. Even though a momentary suffering were considerable, the resultant relief is so immediate, complete, and permanent in most cases that it would be cruelty in the extreme to withhold the lancet.

Lastly, the argument which even professional men use, that thousands of children erupt their teeth without recourse being had to the lancet, is hardly entitled to serious notice. Thousands of women become mothers without the aid of a physician, and there are many practitioners who never use obstetric forceps, but obstetricians and obstetric forceps are nevertheless often necessary. All the arguments noted are offset by the consideration that many infants' lives are probably sacrificed yearly because of popular and professional prejudice against lancing; while, on the other hand, it will not be claimed that death, or even serious trouble, results in one case in thousands from the performance of this simple operation. The suffering, even if unnecessary, is very trifling, the risk hardly computable.

An examination of the mouth should always be made in any case of

illness not plainly accounted for occurring during the teething period. Even in this simple procedure regard should be had to the number of teeth, if any, already erupted, so that the finger may be introduced with reference to avoiding unnecessary contact with sore or inflamed gums. If no teeth have been erupted, the gums over the incisors should not be pressed upon, but the finger should be introduced at the corner of the mouth. On the other hand, if one or more of the incisors are in place, the finger should be introduced at the front.

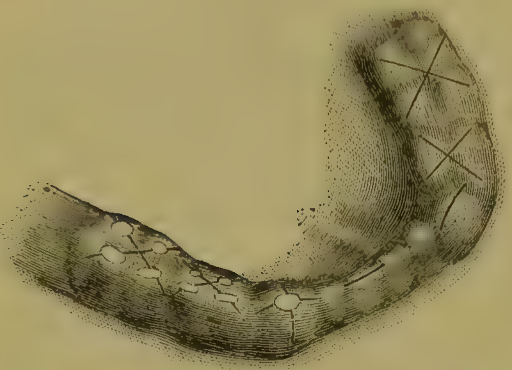
The operation of lancing the gums should, when necessary, be performed in the spirit of the adage, "What is worth doing at all is worth doing well." The operator should be seated directly in front of the assistant, the knees of the two parties corresponding in height. Some direct the child to be held crosswise on the lap of the assistant; others prefer to be behind the head of the child to operate on the left side, and in front to operate on the right side of either jaw. Others take the head on their knees when operating on the upper jaw, and place the head on the knees of the assistant for operation on the lower jaw. In any case the child should be held with such relation to the window or to the artificial light that the parts to be operated upon may be illuminated to the best advantage. The instrument employed should be a curved double-edged bistoury, so protected by wrapping the blade as to avoid injury to the tongue, lips, or cheek. The left hand of the operator should separate the jaws and protect the tongue and lips of the child in such manner that any unexpected movement may result in injury to his own fingers rather than to the child. In the case of a child disposed to bite the insertion of a small cork between the jaws will be of service. This should be guarded from falling into the throat by a piece of string or tape, and should be held in the desired position by the assistant.

The manner in which this trifling operation is performed has much to do with its success or failure. As has been already stated, the object is not merely nor chiefly to induce a flow of blood, but to remove tension. The cuts should therefore be made with special reference to the form of the erupting tooth, and should be sufficiently deep to reach the presenting surface and extend fully up to and a little beyond its boundaries, so as to ensure its entire liberation. Only an *undue* force will be likely to injure the incompletely solidified enamel of the tooth or endanger the germs of the developing permanent tooth. It is well always to direct the point of the lance toward the lips, instead of toward the lingual or palatal surface of the oral teeth, as there is thus less liability to injure the crypts of the permanent teeth if from any cause the cut should be made deeper than intended. The incisors and cuspids need only a division of the gum in the line of the arch. The molars require a crucial incision, the centre of the crown, as near as can be determined, indicating the point of decussation. (See Fig. 101.)

Partial eruption of a tooth is generally accepted as a solution of the problem, the slightest presentation being considered as definitely deciding against the necessity for lancing. This is generally true in the case of the incisors—far from true of the cuspids and molars. The cone shape of the cuspids ensures a persistence of the trouble, from pressure of the enclosing ring of gum, until fully erupted. A complete sever-

ance of this fibrous ring on the anterior and posterior as well as lateral surfaces is indicated, and is even more necessary than before the partial eruption of the tooth. A cuspid is indeed rarely the cause of irritation until after the eruption of its point. All the cusps of a molar may have erupted, and yet strong bands of fibrous integument maintain a resistance as decided as before their appearance. In this case either the boundaries of the tooth should be traced by the lancet, and all such bands severed around its outlines, or a crucial incision should be made so as to ensure perfect release from pressure. In extreme or urgent cases it is sometimes advisable to seize the gum over a presenting molar with a tenaculum and cut out a square block of gum, so as fully to expose the whole articulating surface of the tooth. If the wound should heal readily and the symptoms point to a renewal of the irritation, an early repetition of the operation will be advisable, and may be resorted to with advantage at short intervals until the tooth has completely erupted.

FIG. 80.



Showing Lines of Incison in Lancing: A A, over the molars; B B, over the cuspids and incisors before eruption; C C C, over the molars and cuspids after partial eruption.

Persistent bleeding after lancing, though infrequent, has occurred, and is probably due generally to the sucking of the gums provoked by the taste of the blood. In such cases the substitution of the nipple of the nurse will give the child better employment. The extent of the hemorrhage can be ascertained by touching the wound occasionally with the napkin-covered finger. If the child should refuse to nurse, it can be prevented sucking its gums by the introduction of any soft substance, such as a roll of linen or muslin placed like a bit in the mouth and kept in position by attachments of tape tied around the head. If the bleeding continues longer than seems desirable, a little very finely-powdered alum may be rubbed into the cuts, and will generally be all that is required to control the bleeding. Tannic acid may be employed in the same manner; or fibres of cotton which have been moistened and dusted with one of the vegetable or mineral astringents may be packed into the cuts; or styptic colloid—a saturated solution of tannin and gun-cotton in ether—may be applied with a minute camel's-hair brush over the wounds; or some one of the numerous remedies which act mechanically may be used: lycoperdon, puff-ball, matico, resin in powder, burnt cork, and spider's web are familiar examples. Pressure with the finger over the cuts would be an efficient procedure. As a last resort the actual cautery would promise relief. Nitrate of silver or the perchloride or persulphate of iron should never be used, because of their liability to cause a slough and consequent secondary hemorrhage more difficult to control than the primary bleeding. In an extreme case, to divert the circulation to other parts of the body, hot foot-baths or mustard cataplasms to the extremities may be resorted to, and the feet and limbs kept warm by the application of a

heated brick or flat-iron or by a bottle of hot water. In a case of hemorrhagic diathesis, where a slight oozing of blood persists in spite of local treatment, it would be necessary to administer remedies intended to correct an abnormal condition of the blood and to promote contractility of the blood-vessels. Of the former, the tincture of the muriate of iron is probably the most efficient; of the latter, acetate of lead, aromatic sulphuric acid, gallic acid, ergot, erigeron, and turpentine are of the class from which benefit might be expected. Both indications would be met in the following formula:

℞. Tinct. ferri chloridi, f℥ss;
Acid. acetic. dil. f℥j;
Liq. ammonii acet. f℥j;
Ext. ergot. fld. f℥ij;
Syr. simp. f℥ss;
Aquæ, q. s. ad f℥iij. M.

Dose, a teaspoonful every three hours for a child six months old.

To promote as far as possible the normal eruption of the teeth the requirements which are advisable for the general welfare of the child are indicated with added emphasis — proper clothing, suitable food, abundance of sleep, fresh air and sunshine, judicious ventilation of the nursery, cleanliness, the avoidance of draughts, of nostrums, and sleeping drops, and especially of everything calculated to excite mental and emotional activity. An infant should always have a bed, crib, or cradle, and should never sleep in the bed with the mother or nurse. In this connection it may be noted that a cradle without rockers is to be preferred, and the same objections which apply to cradle-rocking apply with equal force to the senseless jolting upon the knee of the nurse so commonly practised. Infants should be allowed to lie in their cribs a considerable portion of the time, instead of being held in the arms and against the person of the nurse. Cleanliness of the nurse in person and clothing is next in importance to the cleanliness of the child in its influence upon the health of the latter. A teething child should have more than usual hygienic care, more than usual freedom from all avoidable disturbing influences; for whatever tends, by modifying the general health unfavorably, to lower the resisting power of the organism, may readily convert the natural and otherwise easy course of dentition into one of pain and danger. There is unquestionably during the period of dentition an increased susceptibility to nervous and digestive troubles, requiring more than ordinary watchfulness on the part of the mother. Causes which at other times might have no appreciable effect may then be productive of danger. Anything which introduces inharmony into the functions of animal life may result in a disturbance of the processes of dentition.

The brain and nervous system of a child need no stimulation. The danger is that they will develop too rapidly, diverting nutrition from the organic functions and creating a tendency to reflex disturbances which may be excited by trivial causes and lead to disastrous results. The prevailing type of infancy is, it has been said, "big heads, little bodies, and feeble digestive power." Certainly, the tendency of to-day is to a premature activity of the brain at the expense of the organic func-

tions—"to more nervous energy and mental activity, but less physical vitality and less power of endurance. The balance of structure and harmony of function in organization is thus radically changed, and carried to an intense development of nervous tissue which in its very nature is unfavorable to the preservation of offspring."

The clothing of an infant should be such as, while not interfering with respiration and muscular action, will protect the entire body, especially the legs and feet. A fine soft flannel next to the skin, worn in winter and summer, will protect the body from variations of temperature and do much toward preventing catarrhal and other troubles. An entire change of clothing at night is desirable, and in warmth should be at least equal to that worn during the day. As a rule, the heads of children are kept too warm, and the legs and feet are insufficiently protected in outdoor exposure. But, indoors or out, bare neck, arms, or legs should never be permitted. All changes in the clothing or food of a child should be made gradually, so as not unnecessarily to disturb its functions.

The food of an infant for the first few months after birth should consist exclusively of milk. Always, when possible, it should be nursed by the mother; when that is impracticable, by a wet-nurse. But the mother or the nurse must herself be in good health or her milk may be unwholesome. Undue fatigue, excitement, or improper diet may not only interfere with the secretion as to quantity, but destroy its nutritive properties and render it harmful to the infant. When human milk cannot be obtained, cow's milk should be substituted. Condensed milk may answer for a short time and under peculiar circumstances, when fresh and pure milk of the cow cannot be obtained, but should not be relied upon as a steady diet. When circumstances make it desirable to give condensed milk, care should be taken that it be not used in excess. A small teaspoonful is enough to make four ounces of rich milk. Barley-water makes a useful diluent for this preparation. Arrowroot, corn starch, and other farinaceous foods are positively injurious to a child under three months of age. The secretion of saliva before that period is scant, and is, moreover, deficient in the property which is essential to produce the change required in starchy foods to fit them for digestion; and this property is not fully developed in the saliva until the child is about a year old. A very small quantity of one of the farinaceous preparations may be advantageously added to milk, simply to prevent the tendency to the formation of large curds, but in any considerable quantity it is absolutely hurtful, and dependence upon farinaceous food as a staple will almost surely produce intestinal trouble. It will fail, moreover, to supply the essential elements for the building of the osseous and muscular structures. As a food it only makes fat and produces heat. After the child is nine months of age, if weaned, milk should still be made the staple, but the diet may be varied by the addition of oatmeal boiled to a jelly, wheaten grits, barley flour, rice, farina, sago, breadcrumbs, the yelk of egg with milk, and chicken or mutton broth. After two years of age bread and butter, baked potatoes, and ripe fruits may be gradually added. But milk should still be the staple until three years of age. While, on the one hand, confinement to any

one article of food, unless it be pure rich milk, should be avoided, and a varied diet allowed, care should be taken, on the other hand, to exclude those substances which contain but little nutriment or are difficult of digestion, such as pastry, confectionery (unless of the simplest forms), cabbage, turnips, the skins or rinds of fruits, etc. Most children are fed too often and too much. The resulting indigestion is the fruitful cause of disorders of the stomach and bowels, and if such disturbance be added to the prostrating effects of summer weather, and especially at the teething period, a formidable complication is presented. Too much stress can hardly be placed on the evil of overfeeding—a mistake so common that intelligent observers have estimated it as the chief cause of the mortality of infancy. No uniform rule can be laid down as to the quantity of food to be allowed. The amount will vary with the age and constitution of the child. As an approximate guide it may be assumed that a healthy infant will require from twelve to sixteen fluidounces daily during the first month, increasing during the second and third months to twenty-four ounces, and after that to two or even three pints. Of course, strength and quantity bear a relation which must be taken into the account. For infants brought up by hand the addition of lime-water to the milk neutralizes the acid secretions of the stomach and intestines and serves to prevent colic and diarrhœa. To boil milk makes it more difficult of digestion.

The amount of dilution which cow's milk should receive depends on the character of the milk and the age and condition of the child. If the milk be pure and rich, it should be diluted one half for the first six weeks of life, and one third from six weeks to four months. As long as milk forms the staple of the feeding the addition of lime-water to each meal's allowance will be beneficial.

Within the limits designated it is well to vary the food of a child artificially fed, and all its food should be moderately salted. The addition of some mucilaginous article, such as gum-acacia or gelatin, is highly recommended by some practitioners. Pure cool (not cold) water is generally very acceptable to an infant, and happily supplies the physiological demand for fluids and prevents it from overloading its stomach in nursing. It should be remembered that milk rapidly absorbs odors and septic germs, and quickly ferments and sours. It should be kept in scrupulously clean vessels and intelligently guarded from all contaminating influences. Unless assured of its perfect sweetness it would be well always to test it by litmus-paper. Scrupulous cleanliness of the nursing-bottle is required. The plain white glass feeding-bottle with a rubber nipple as sold in the shops is to be preferred to all complex feeding apparatus with glass or rubber tubing, and the child should be encouraged to use it until of an age when solid or semi-solid food may be allowed. The bottle should never be used a second time without previous washing with scalding water, after which it should be filled with a solution of bicarbonate of soda, and this should be allowed to remain in it until it is again wanted for use. It is well to keep both bottle and nipple in duplicate and use them alternately. The rubber nipple should be turned inside out after using, washed clean, and kept in a solution of bicarbonate of soda until again needed.

To discuss the various theories relating to the best substitute for woman's milk would far outrun the limits of this chapter. An excellent formula is that proposed by the late Dr. J. Forsyth Meigs—equal parts of milk, cream, lime-water, and oatmeal, barley- or arrowroot-water, a little sugar of milk being added. The barley may be employed preferably for children who manifest a tendency to diarrhœa, the oatmeal for those who have a tendency to constipation, changing from one to the other according to changes in the intestinal functions. The oatmeal or barley should be thoroughly boiled—a teaspoonful of either to a pint of water evaporated by boiling, preferably in a water-bath, to half the quantity, and strained through muslin. With some children cracked wheat, treated in the same manner, seems to answer better than either oatmeal or barley. If a tendency to constipation is not overcome by the use of oatmeal as suggested, the administration of sweet oil two or three times daily, in doses of from twenty drops to a teaspoonful according to age, will probably correct the difficulty. In adynamic or scrofulous conditions cod-liver oil might be substituted with advantage. Dr. Arthur V. Meigs recommends two parts of cream, one of milk, two of lime-water, and three parts of a solution of sugar of milk of the strength of $17\frac{3}{4}$ drachms to the pint of water.

Meigs and Pepper[1] recommend a preparation made by dissolving a small quantity of prepared gelatin or Russian isinglass in water, to which is added milk, cream, and a little arrowroot or any other farinaceous substance that may be preferred. They say: "We have given this food to a great many children during the last twenty-five years, as well to those brought up by hand as those partly suckled or weaned, and can truly state that they have thriven better upon it than upon anything else we have employed." The mode of preparation and the proportions are as follows: "A scruple of gelatin (or a piece two inches square of the flat cake in which it is sold) is soaked for a short time in cold water, and then boiled in half a pint of water until it dissolves—about ten or fifteen minutes. To this is added with constant stirring, and just at the termination of the boiling, the milk and arrowroot, the latter being previously mixed into a paste with a little cold water. After the addition of the milk and arrowroot, and just before the removal from the fire, the cream is poured in and a moderate quantity of loaf sugar added. The proportions of milk, cream, and arrowroot must depend on the age and digestive power of the child. For a healthy infant within the month we usually direct from three to four ounces of milk, half an ounce to an ounce of cream, and a teaspoonful of arrowroot to a half pint of water. For older children the quantity of milk and cream should be gradually increased to a half or two-thirds milk and from one to two ounces of cream. We seldom increase the quantity of gelatin or arrowroot."

Dr. Eustace Smith speaks highly of "barley jelly," made as follows: Put two tablespoonfuls of washed pearl barley into a pint and a half of water and boil down to a pint; next strain out the barley and let the liquid set to a jelly. Two teaspoonfuls of this dissolved in eight fluidounces of warmed and sweetened milk are enough for a single

[1] *Practical Treatise on the Diseases of Children.*

feeding, and such a meal may be allowed twice a day after the eighth month.

The following is the formula suggested by Prof. Leeds of Stevens Institute as the best substitute for woman's milk:

1 gill of cow's milk, fresh and unskimmed;
1 " of water;
2 tablespoonfuls of rich cream;
200 grains of milk-sugar;
$1\frac{1}{4}$ " of extractum pancreatis;
4 " of sodium bicarbonate.

Put these in a nursing-bottle; place the bottle in water made so warm that the whole hand cannot be held in it without pain longer than one minute. Keep the milk at this temperature for twenty minutes. The milk should be prepared just before using.

Dr. J. M. Keating considers that pancreatized milk has solved the much-discussed problem of the artificial feeding of children, and does not think that there is any occasion to ask or look for a more suitable food. He gives the following directions for its preparation: In a gill of water dissolve five grains of extractum pancreatis; add this to a pint of milk at a temperature of 110° F. The pancreatin is first put in water, because it contains a curdling ferment that is weakened by water; or the baby's bottle can be filled with milk and brought to the proper temperature by setting it in warm water, and the solution of pancreatin added in proper proportion—namely, a gill to a pint.

An old-time formula, which has been recently indorsed by Dr. J. Lewis Smith, is as follows: Pack a pound of dry wheat flour, preferably unbolted, into a firm muslin bag; tie the neck of the bag so as to confine the flour tightly, and place it in a suitable vessel, in which it is to be covered with water and boiled constantly for ten hours. After it is removed hang the bag up to dry. The outer part of the flour ball can then be peeled off, leaving a lump looking something like yellow chalk. This should be scraped into a powder, a tablespoonful of which should be mixed with twelve tablespoonfuls of water and heated. For a child six months of age half a teaspoonful of extract of malt and a little salt should be added. White of egg or a little raw beef-juice may be added if more nourishment is needed. This food may be resorted to when a change seems desirable, especially when the bowels are out of order, or may be alternated with peptonized milk.

Dr. Louis Starr gives the following directions for the preparation of "flour-ball" food: Rub a teaspoonful of the powder with a tablespoonful of milk into a smooth paste, then add a second tablespoonful of milk, constantly rubbing until a cream-like mixture is obtained: this is poured into eight ounces of hot milk, stirring well, and is then ready for use.

Dr. Eustace Smith recommends the following preparation, which he considers especially useful to supplement the mother's milk when that is insufficient: One tablespoonful of cream, one of whey, and two of hot water. Whey is made by adding a large teaspoonful of wine of pepsin to a pint of fresh milk, allowing it to stand by the fire a couple of hours, then straining through muslin.

Dr. Louis Starr recommends the following as the best substitute for the mother's milk in gradual weaning of a child, say at ten months; it may also be employed to supplement the breast when the mother's milk is insufficient:

Cream,	f℥ss;
Milk,	f℥iiss;
Sugar of milk,	ʒss;
Water,	f℥j.

Should this quantity fail to satisfy the child, all the ingredients except the cream may be increased until the mixture measures six, eight, or twelve ounces.

Mellin's Infant Food is an English preparation which agrees admirably with many children. Horlick's Food, made in this country, is very similar. Either may be added in small quantity tentatively to the milk of a hand-fed infant after the fourth or fifth month.

At times milk in any and every form seems to disagree with a child. In such cases it should be withheld, and a temporary substitute given until its use can be safely resumed. Such substitutes are to be found in Mellin's and Horlick's Foods, barley jelly, broths, and beef-tea (peptonized if necessary), the white of raw eggs stirred in water, etc.

The accurate adaptation of diet is by no means an easy task in many cases, and only general rules can be given, which must be modified in individual instances where they do not seem to be successful. The object is to keep up the nutrition of the body with the least irritation to the digestive organs, and the food which will best serve these purposes is the best.

The annexed diet list[1] will be found of service as indicating a conservative regimen:

Diet of Children in Health.

Diet 1.—From birth to six months; if child be nursed, nurse's milk, and *no other food.*

Nurse every two hours for first six weeks; six weeks to four months, every three hours.

From four months till two, four, or six teeth are cut, every four hours, when additional food may be given. (See *Diet 3.*)

During the whole time of nursing never nurse later than 11 P.M. or before 5 A.M.

After the teeth appear, no nursing at night, but continuing through the day till weaning, gradually lengthening the intervals.

Diet 2.—For infants brought up by *hand,* three or four ounces of fresh unskimmed milk and lime-water, with one teaspoonful of sugar of milk, the mixture to be tepid.

For first six weeks, half lime-water, and every two hours.

From six weeks to four months, one-third lime-water, and every three hours.

From four months till two, four, or six teeth are cut, every four hours.

N. B.—If the infant can be only *partially* nursed, nurse twice a day, and for other meals follow Diet 2.

[1] Dr. E. S. Dunster.

Diet 3.—From seventh or eighth month (when two, four, or six teeth are through) to one year, *five meals.*

6 OR 7 A. M.—A cup of *pure* milk (if digested), with two teaspoonfuls of farina, oatmeal, wheaten grits, rice or rizena, barley flour. It is well to alternate rice with oatmeal or farina.

11 A. M.—Milk with breadcrumbs, milk crackers, or rusk. Twice a week the yelk of one egg, beaten with teacup of milk, may be given with the bread and milk, etc., juice of raw beef, heated a little, or beef-tea, chicken or mutton broth, in small quantity. At about ten months, a piece of rare beef or chicken bone to suck.

2 P. M.—One cup of milk, with lime-water, if necessary.

5 P. M.—Same as at 7 A. M.

11 P. M.—*If needed*, same as at 2 P. M.

A healthy child, between ten and twelve months old, requires a pint and a half to one quart of milk in twenty-four hours.

Diet 4.—From one year to eighteen months.

7 A. M.—Same as Diet 3, at 7 A. M., or with a rusk, slice of bread, well soaked in milk.

11 A. M.—A drink of milk, slice of bread and butter, rusk, or crackers.

1 P. M.—A cup of beef-tea or piece of rare beef, chicken or mutton broth, with bread, rusk, or milk crackers; a mealy potato, moistened with beef gravy; one or two tablespoonfuls of light pudding, rice, rizena, corn starch, or sago, made with milk.

6 P. M.—Same as 7 A. M.

11 P. M.—A drink of milk, *if required.*

A healthy child, between one year and eighteen months, will take two or three pints of milk in twenty-four hours.

Diet 5.—From eighteen months to two years.

7 A. M.—Cup of milk, rusk, bread and butter; occasionally yelk of one egg.

11 A. M.—A cup of milk or rice and milk, with ripe fruit occasionally.

1 P. M.—Rare beef, broths, soups not too rich, baked potatoes, with gravy, milk, or toast-water, or simply water as drink; small quantity of custard or other light pudding.

6 P. M.—Bread and butter, rice (or rizena) and milk, occasionally stewed fruit.

Between two and three years, same diet may be continued, substituting 11 A. M. and 1 P. M. meals for one at 12 M. Meat can be given every day; vegetables, except cabbage, turnips, and parsneps; morning and evening, principally milk.

The following schedule of the diet of a hand-fed infant from birth upward[1] will serve as a suggestive and useful guide:

Diet during the First Week.

Cream,	f℥iij;
Sugar of milk,	gr. xv;
Whey,	f℥ss, f℥ij;
Water,	f℥ss, f℥ij.

This portion to be given every two hours from 5 A. M. to 11 P. M., and in some instances once or twice during the night.

[1] *Diseases of the Digestive Organs in Infancy and Childhood*, by Louis Starr, M. D.

Diet from the Second to the Fifth Week.

Milk,	f℥ss;
Cream,	f℥ij;
Sugar of milk,	gr. xv;
Water,	f℥j.

This portion to be given every two hours from 5 A. M. to 11 P. M.

Diet from the Fifth Week to the End of the Second Month.

Milk,	f℥j, f℥ij;
Cream,	f℥ss;
Sugar of milk,	gr. xxx;
Water,	f℥j, f℥ij.

This portion to be given every two hours.

Diet during the Third Month.

Milk,	f℥iiss;
Cream,	f℥ss;
Sugar of milk,	ʒj;
Water,	f℥j.

This portion to be given every two and a half hours.

Diet during the Fourth and Fifth Months.

Milk,	f℥iiiss;
Cream,	f℥ss;
Sugar of milk,	ʒj;
Water,	f℥j.

This portion to be given every three hours.

Diet during the Sixth Month.

Milk,	f℥ivss;
Cream,	f℥ss;
Sugar of milk,	ʒj;
Water,	f℥j.

This portion to be given four times daily. Two other meals—morning and mid-day—may be as follows:

Milk,	f℥ivss;
Cream,	f℥ss;
Mellin's Food,	ʒj;
Hot water,	f℥j.

Dissolve the Mellin's Food in the hot water, and add, with stirring, to the previously-mixed milk and cream.

In the *seventh month* the Mellin's Food may be increased to two teaspoonfuls and given three times daily.

Throughout the *eighth* and *ninth months* five meals a day will be sufficient —at 7 and 10.30 A. M., 2, 6, and 10 P. M.

Milk,	f℥viss;
Cream,	f℥ss;
Sugar of milk,	ʒj;
Water,	f℥j.

This portion for the first and last meals. For the other three meals a tablespoonful of Mellin's Food may be added, or a teaspoonful of "flour ball" may be given twice daily instead of the Mellin's Food—say at the second and fourth meals.

Diet for the Tenth and Eleventh Months.

First meal, 7 A. M.:

Milk,	f℥viiiss;
Cream,	f℥ss;
Mellin's Food,	℥ss;
(Or "flour ball" or barley jelly,	ʒij);
Water,	f℥j.

To be used only when Mellin's Food is employed.

Second meal, 10.30 A. M.: Eight ounces of warm milk.

Third meal, 2 P. M.: The yelk of an egg lightly boiled, with stale breadcrumbs.

Fourth meal, 6 P. M.: Same as first.

Fifth meal, 10 P. M.: Same as second.

On alternate days the third meal may consist of a teacupful (f℥vj) of beef-tea, containing a few stale breadcrumbs.

Beef-tea for an infant is made in the following way: Half a pound of fresh rump steak, free from fat, is cut into small pieces, and put with one pint of cold water into a covered tin saucepan. This must stand by the side of the fire for four hours; then be allowed to simmer gently (never boil) for two hours, and finally be thoroughly skimmed to remove all grease.

A further variation can be made by occasionally using mutton, chicken, or veal broths instead of beef-tea.

Diet from the Twelfth to the Eighteenth Month (Five Meals per Day).

First meal, 7 A. M.: A slice of stale bread broken and soaked in a breakfast cup (f℥viij) of new milk.

Second meal, 10 A. M.: A teacup of milk (f℥vj), with a soda biscuit or thin slice of buttered bread.

Third meal, 2 P. M.: A teacupful of beef-tea (f℥vj), with a slice of bread, one good tablespoonful of rice, and milk pudding.

Fourth meal, 6 P. M.: Same as first.

Fifth meal, 10 P. M.: One tablespoonful of Mellin's Food, with a breakfast-cupful of milk.

To alternate with this:

First meal, 7 A. M.: The yelk of an egg slightly boiled with breadcrumbs; a teacupful of new milk.

Second meal, 10 A. M.: A teacupful of milk, with a thin slice of buttered bread.

Third meal, 2 P. M.: A mashed boiled potato moistened with four tablespoonfuls of beef-tea; two good tablespoonfuls of junket.

Fourth meal, 6 P. M.: A breakfast-cupful of new milk, with a slice of bread broken up and soaked in it.

Fifth meal, 10 P. M.: Same as second.

The fifth meal is often unnecessary, and sleep should not be disturbed for it. At the same time, should the child awake an hour or more before the first meal-time, he should break his fast upon a cup of warm milk, and not be allowed to go hungry until the set breakfast hour.

Diet from Eighteen Months to the End of Two and a half Years (Four Meals a Day).

First meal, 7 A. M.: A breakfast-cupful of new milk; the yelk of an egg lightly boiled; two thin slices of bread and butter.

Second meal, 11 A.M.: A teacupful of milk, with a soda biscuit.

Third meal, 2 P.M.: A breakfast-cupful of beef-tea, mutton or chicken broth; a thin slice of stale bread; a saucer of rice and milk pudding.

Fourth meal, 6.30 P.M.: A breakfast-cupful of milk with bread and butter.

On alternate days:

First meal, 7 A.M.: Two tablespoonfuls of thoroughly cooked oatmeal or wheaten grits, with sugar and cream; a teacupful of new milk.

Second meal, 11 A.M.: A teacupful of milk, with a slice of bread and butter.

Third meal, 2 P.M.: One tablespoonful of underdone mutton pounded to a paste; bread and butter, or a mashed baked potato moistened with good plain dish gravy; a saucer of junket.

Fourth meal, 6.30 P.M.: A breakfast-cupful of milk, a slice of soft milk toast, or a slice or two of bread and butter.

The foregoing schedule must, of course, be regarded as an average. Many children can bear nothing but milk food up to the age of two or even three years, and provided enough be taken no fear for their nutrition need be entertained. The rule to adopt is, if a child be thriving on milk he is never to be forced to take additional food merely because a certain age has been reached. Let the healthy appetite be the guide.

Unless for reasons which outweigh the disadvantages, such as the pregnancy of the nurse, a child should not be weaned until it has erupted twelve teeth. In case of the pregnancy of the nurse it should be weaned at once. If possible to avoid it, a child should not be weaned just before or during hot weather. If there is a necessity for weaning it, compensation for the deprivation of the mother's milk would be secured to a large extent by its removal, if living in a large city, to the country or to the seaside. The extreme heat of midsummer is especially trying to infants, and choleraic symptoms, with a tendency to collapse, are frequently excited without other apparent cause. When practicable, children under twelve months of age should always have the benefit of country air during a long-continued heated term.

Derangements of health that are simply coincident with dentition are to be treated on general principles, but the liability of reflected dental irritation to exaggerate and complicate systemic disorders should always be borne in mind, and local relief afforded when indicated. The application of a saturated solution of bromide of potassium or of equal parts of phénol sodique and paregoric to the gums is soothing, and may be employed with the view of lessening whatever sense of discomfort may arise from the activity of the eruptive forces where no undue pressure upon or by the gums is suspected. In case of apparent distress arising presumably from a hyperæsthetic condition of the gum-tissues favorable results may be anticipated by brushing the surfaces at suspected points with a 4 per cent. solution of oleate of cocaine. In the presence of symptoms seemingly out of proportion to any recognized cause of disturbance it would still be proper to lance the gums over the teeth next in order of eruption, though local signs did not appear to demand it.

A febrile condition—the so-called irritative fever of infancy—is produced by various and frequently by slight causes. The process of teeth-

ing, indigestible food, worms, a misplaced pin, continued pressure as by a string or bandage, any considerable irritation of the cutaneous surface, will excite a more or less severe fever in proportion to the predisposing conditions present.

The nervous system in infancy is exceedingly excitable, and the sympathetic system of nerves is especially responsive. Peculiarities of the pyrexia of dentition are its severity, its irregularity, and the excitability attending it. Children are not infrequently delirious from the febrile disturbance consequent on dentition. This excitement, like all other disorders dependent upon tension from dentition, is best allayed by a removal of the tension. This is generally all that is required. If, however, the cutaneous surface becomes hot and dry, advantage will be found in bathing the child once or twice daily with warm water to which has been added alcohol, bay rum, or vinegar. Bathing the child's head frequently with cool water is an efficient aid in preventing a tendency to congestion. Inunction of the child's body with warm oil (an animal oil, or even sweet oil) has a very soothing effect, and will frequently, in hyperæsthetic conditions, ensure a quiet night.

If systemic treatment is required, the appropriate remedies will be refrigerants and sedatives, such as cool water, the neutral mixture, bromide of potassium, spirit of nitrous ether, compound spirit of ether, etc. An irritative fever of sufficient severity or duration to excite functional disturbance or organic changes must be treated on general principles, though the exciting cause should always be found and corrected if possible.

Spasms or convulsions may be coincident with or incident to dental evolution. Various causes, singly or in association, may produce such an irritation of the spinal centres that the co-ordinating function of the brain is overpowered, and irregular muscular actions, spasms, or convulsions may ensue. Of these causes none are more liable to act as excitants of convulsive attacks than irritations of the fifth and pneumogastric nerves. Oftener than from any other causes spasm is the indication either of irritation in the field of distribution of the fifth nerve or of gastric or intestinal disturbance. The condition of the mouth, therefore, and of the alimentary tract is to be considered in every case of convulsions not otherwise plainly accounted for. An overloaded stomach, or the presence of indigestible food, is perhaps the most frequent factor in the etiology of eclampsia. A convulsive attack is generally preceded by unusual and irregular movements of the eyelids, twitching of the corners of the mouth, and almost always by a contraction of the toes and turning of the thumbs into the palms of the hands; frequently by a strabismus of one or both eyes, and sometimes by spasmodic movements of the limbs.

The first indication for treatment is to remove the irritation—by the lancet, emesis, purgatives, etc., according to diagnosis. Further treatment may include the hot bath and general bloodletting, though the latter is seldom advisable. Here, again, after the removal or correction of the causative irritation, antispasmodics and nervous sedatives, such as have been enumerated, will be beneficial if judiciously employed; and to them may be added chloroform, ether, chloral, asafœtida, cam-

phor, valerian, belladonna, opium, etc., according to the condition of the little patient. As a rule, bromide of potassium is the most efficient agent, unless a more prompt remedy is required. A valuable combination is to be found in the following formula:

℞. Potassii bromid.
Sodii bicarb. *āā*, gr. xvj;
Chloral hydrat. gr. iv–viij;
Aquæ menth. pip. f℥j. M.

Dose, a teaspoonful every two hours at six months.

The indication is to lessen the nervous excitability by controlling the nerve-centres. The tendency in the individual case should be combated according as anæmia or plethora is manifested. In the one case tonics, and in the other salines and restricted diet, are indicated.

The manifestations of reflex excitability are numerous and varied. Occasionally the peripheral irritation is reflected to the genito-spinal centre, causing priapism and a picking or pulling at the penis by the child. Retention or incontinence of urine and painful and difficult micturition are sometimes apparently dependent upon reflected dental irritation. In such cases demulcent drinks—barley-water, flaxseed-tea, or solution of gum-acacia, sweet spirit of nitre, or citrate of potassa, and, if there is much pain, a half drop of tincture of opium occasionally—will usually correct the condition. Spasm of the glottis (laryngismus stridulus) appears sometimes to be excited by the irritation of teething. There is reason to believe that earache is often associated with and dependent upon the difficult eruption of one or more teeth, and that, apart from the aggravation of the fever and the increased liability to convulsions incident to this added anguish, there is also the possibility of the loss of hearing (entailing in young children the loss of speech) from the congestion and inflammation which result. But this is not the only—indeed, not the chief—danger. The inflammation is liable to extend to the membranes of the brain and end in death. The facility with which an irritation originating in the mouth may be continued to the ear, and thence to the brain, can readily be understood by a recognition of the intimate relations which exist between the parts concerned and of their elaborate nervous connections. The danger is a real one, and should not be lost sight of in the treatment of a child suffering from teething. The relief of the excitant cause is here also the important ameliorative or curative procedure. There seems little room to doubt that infantile paralysis is in some instances more or less directly connected with teething. Cases are recorded of paraplegia appearing at the cutting of each tooth and disappearing after its eruption. Infantile paralysis usually takes the form of incomplete paraplegia, sometimes affecting a single group of muscles or even an individual muscle. It generally occurs suddenly. Its duration varies greatly, from a few days or weeks to months, and in some cases it persists throughout life.

In all infants, especially in those artificially fed, there is a tendency to an acid fermentation of their food, due partly to the character of the food and partly to the peculiar activity of the mucous glands, either in response to a local irritant or to a reflex impression causing a modified secretion, or to an extension of a local irritation. Flatulence, pain,

vomiting, and diarrhœa are the natural results of this condition of the alimentary tract. Attention to the condition of the mouth, to the hygienic management of the infant, and especially to its diet as to quantity, quality, and frequency, should precede the employment of drugs. A flannel bandage around the abdomen will serve as a derivative, and if desired may be made more effective by rubbing powdered spices or dry mustard on the surface next the belly or by sprinkling it with turpentine mixed with sweet oil. A change or modification of diet is frequently advisable, and a change of air will often act like a charm. Under all circumstances it is well to limit the amount of food to the quantity just sufficient to sustain life, in order to afford the digestive organs physiological rest. The union of an alkali with an aromatic is indicated, and a grain of the bicarbonate of sodium or of potassium with anise, cinnamon, or caraway will prove of advantage if given with each meal until the condition is corrected. If undigested food or vitiated secretions in the alimentary tract are suspected, a dose of castor oil and aromatic syrup of rhubarb in equal portions—a teaspoonful of the mixture—will be of great service. If torpidity of the liver is diagnosed, a few doses, at intervals of two hours, of the twelfth or sixteenth of a grain of calomel, with one to two grains of sodium bicarbonate, will be likely to correct the condition. If the diarrhœa persists after the action of the purgative, the following prescription may be employed, first prohibiting the use of any farinaceous or milk food. Indeed, if all food be withheld for from two to six, eight, or even ten hours, and be then given in very small quantities, the effect on the digestive tract will be very beneficial:

℞. Tinct. opii, gtt. viij ;
Bismuth. subnitrat. ʒj ;
Mucilag. acaciæ, f℥ss ;
Aquæ menth. pip. f℥iss. M.

Dose, a teaspoonful every three hours to a child six months old.

Opium is indicated, however, only after all offending matters have been expelled from the alimentary canal. Its chief value then is to lessen peristaltic action ; but it is at best a choice of evils in the maldigestion of infancy, because of its interference with the normal secretion of the digestive fluids. Opium is sometimes beneficial when combined with small doses of a purgative—a half drop of laudanum to twenty or thirty drops of a mixture in equal proportions of castor oil and spiced syrup of rhubarb, given three or four times daily.

If the stools are serous and alkaline, the following mixture may be given :

℞. Acid. sulph. aromat. gtt. viij ;
Spt. vini gallici, fʒij ;
Syr. acaciæ,
Aquæ menth. pip. *āā*, f℥ss. M.

Dose, a teaspoonful every two hours in a little water.

Or two drops of the wine of ipecac in an ounce of water may be given, in teaspoonful doses, every half hour, to control the vomiting. If the irritability and vomiting are excessive, the following formula may be resorted to :

℞. Spt. chloroformi, f℥j;
Creasoti, ♏ij;
Vin. ipecac. ♏v;
Aquæ anisi, q.s. ad f℥ij. M.

Dose, a teaspoonful in a little water for a child a year old.

A diarrhœa due apparently to relaxation from long-continued warm weather or succeeding to cholera infantum, and not attended by fever, is likely to be controlled by such a combination as the following:

℞. Ext. hæmatoxyli, gr. xvj;
Tinct. opii camph. f℥j;
Mist. cretæ,
Aquæ cinnamomi, *āā*, f℥j. M.

Dose, a teaspoonful in water every four hours for a child six months old.

If the diarrhœa seems to depend upon reflex nervous impression, sedative treatment is indicated, and bromide of potassium, liquor potassii citratis, liq. ammonii acetatis, compound spirit of ether, the camphorated tincture of opium, and even depressants, such as aconite or veratrum viride, may be required; but the latter class of drugs should be given in very small doses and the effects carefully watched.

A diarrhœa dependent on reflex action from dental irritation and consequent irritability of the nerve-centres is usually characterized by profuse and watery dejections (which have a sour smell, indicative of fermentation, caused probably by an arrest of the functions of the intestinal glands), by irritable stomach, anorexia, hot head, cold hands and feet, fretfulness of temper, and restlessness. These conditions, if not corrected, are likely to eventuate in convulsions or congestion of the brain, but are frequently promptly relieved by remedies addressed especially to the nervous system. A combination of bromide and nitrate of potassium is an efficient remedy in such cases:

℞. Potassii bromidi, gr. xviij–ʒss;
Potassii nitratis, gr. vj;
Sacchari lactis, ʒss.

M. ft. pulv. vj.

One of these powders may be given every three or four hours to a child one year of age.

Dr. Lees of London has called attention to a class of cases not very uncommon in children, in which the main symptom is the frequent passage of semi-solid stools, generally containing undigested food. Dr. Lees considered that these symptoms were due to a hyperperistalsis of the alimentary canal from irritation of the vagus nerve which supplies the excitor fibres to the intestine, the splanchnics conveying the inhibitory fibres. The proximity of the nucleus of the vagus to that of the trigeminus in the medulla indicated the possibility that this increased excitability of the intestine might be due to dental irritation. On the theory of the purely neurotic origin of the symptoms he treated these cases with bromide of potassium simply, without opium or astringents, and with immediate success.

Dr. Christopher Elliott recommends the infusion of chamomile-flowers as highly beneficial in infantile diarrhœa when proceeding from dentition and when the stools are greenish in color or are slimy and streaked

with blood. It will quickly calm a fretful child. The dose of the infusion is a half to one drachm for a child under one year; for a child over that age, double, three times a day or oftener according to the severity of the attack. The rationale of the treatment is the power which chamomile-flowers possess of subduing reflex excitability, this power belonging to the volatile oil they contain.

Constipation, whether incident to or coincident with teething, is, if obstinate, to be treated with laxative enemata, suppositories of cocoa-butter, tallow, or molasses candy, or by castor oil by the stomach or by abdominal inunction. A persistent tendency to constipation may be combated by the administration of cod-liver oil, beginning with ten-drop doses three times daily, and increasing, if necessary, to a small teaspoonful. Further treatment, if the troubles persist, should follow on general principles.

Inflammation of the mucous membrane of the mouth, with an increased acidity of the secretions, is a common pathological affection in infants, especially in those artificially fed, and still more especially in those accustomed to farinaceous foods. Varieties in expression of such disorders are designated, according to their character, as simple or erythematous stomatitis, follicular stomatitis or aphthæ, ulcerative stomatitis, gangrene of the mouth, and thrush. Either of these forms may be coincident with, if not incident to, dentition, and may therefore receive brief notice in this connection. Some of them are always, any of them are likely to be, associated with, if not caused by, gastric and intestinal derangement. The simple form requires only the use of demulcent and mildly astringent lotions applied gently to the parts by a camel's-hair brush or by a soft linen rag on the finger, so as to avoid injury to the mucous membrane. Aphthæ occur in two forms—the discrete and the confluent. The simple form is usually accompanied by symptoms of gastric derangement, requiring regulation of the diet and possibly laxatives. The local treatment indicated is demulcents and astringent washes. Glycerin and borax or alum, combined, are efficacious as local applications. The ulcers in the confluent form may require in addition a light application of a stick of nitrate of silver, and in morbid systemic conditions the administration of tonics and stimulants, such as iron, quinia, and brandy. Ulcerative membranous stomatitis (the cancrum oris of some writers) is supposed to be due to epidemic influences, and is sometimes fatal by reason of its extension to the pharynx and larynx. The treatment consists of regulation of the bowels, simple but nutritious food, tonics, and chlorate of potassium, conjoined with demulcent washes and astringent applications. Gangrene is a rare disease in private practice, but not infrequent in hospitals for children. It requires the most energetic nutritive, tonic, and stimulant systemic treatment and escharotics locally. Thrush is generally dependent upon a morbid condition of the digestive functions, and is almost never found in children who have been exclusively suckled. The disease is associated with the growth of a peculiar fungus, the Oidium albicans. It is comparatively rare, except in hospitals and among the children of those who are too poor to give them proper attention, and those fed on feculent food. The severe form is attended with fever, colic, diarrhœa, and

vomiting, and sometimes death results from abdominal complications. The abandonment of improper food and the substitution of proper alimentation are first necessary, following with remedies addressed to the correction of the disordered condition of the alimentary canal, and astringent applications locally. In any of these varieties of disease in the mucous membrane of the mouth the employment of solutions of the sulphite of sodium and of phénol sodique, of strength according to indications—say, as in the following formulæ—promises favorable results so far as local treatment is concerned:

℞. Sodii sulphitis, gr. xxx;	℞. Phénol sodique, f℥ss;
Glycerini,	Glycerini,
Aquæ, *āā*, f℥ss. M.	Aquæ, *āā*, f℥iss. M.

Either formula may be used on a swab every two hours.

Syphilitic stomatitis requires specific treatment.

Cool applications to the mouth are always agreeable and beneficial. The child may be allowed to suck small pieces of ice or the mouth may be frequently syringed with ice-water.

Cutaneous eruptions frequently occur during the period of dentition. These may be symptomatic or idiopathic, from local or constitutional causes. Heredity, predisposition, improper food or excess in feeding, derangement of the alimentary tract, uncleanliness or too frequent bathing, strongly alkaline or impure soap, or too much friction in washing or drying the child, excessive swaddling and consequent heating and sweating, clothing too tightly worn or of irritating material, or made so by dyes used in its manufacture, may produce a cutaneous disease. Derangement of the nervous system, of which dentition may be the exciting cause, is accountable for a variety of cutaneous disorders; but while dental irritation may thus indirectly develop a skin disease, the treatment, except in so far as the removal or correction of the exciting cause is concerned, differs not from that which would be proper if a like disturbance of the nervous system from any other cause had resulted in a like pathological condition.

THE CAUSES OF CONGENITAL DEFECTIVENESS AND DEFORMITY OF THE TEETH.

By ALTON HOWARD THOMPSON, D. D. S.

All aberrations of form or structure, all deviations from normal types of organs or of tissues, in respect either to completeness of quantity or perfection of quality, are the results of abnormal nutrition due to the irregular operation of the formative organs or to the insufficiency or vitiated condition of the nutrient pabulum.

Normal performance of the office of tissue-building by normal formative organs duly supplied with normal nutritive fluids can eventuate only in the production of normal results; and, conversely, malformed and imperfect structures cannot ensue from the union of the normal elements of creation, and normal structures cannot succeed to disease and abnormality. Health must spring from health, and disease can produce only disease.

Nutrition is the basis of the creative function. The genesis of organs and the evolution of tissues depend supremely upon the constancy and perfection of the nutritive supply. This must be unfailing in quantity, regular in flow, and perfect in quality. It must contain all the elements, organic and inorganic, of the various tissues, or the materials from which those elements can be elaborated. It must also be filled with the potency of life—not a mere chemico-physiological mass without vivifying power, for to give life it must possess life, to build living tissues the nutritive plasma must itself be living, and much depends upon the degree of this vital power present in the tissue-foods. It often makes the difference between healthful and diseased nutrition, between perfect and imperfect development. If the nutritive fluids are in full vigor and health, the products of the tissue-builders are vigorous and healthful; if they are diseased, the tissues formed from them partake of the imperfection.

In embryonic growth certain organs and tissues are appointed to the work of creating the permanent organs and tissues of the organism, which when woven together form the unit of the species. It is the function of these organs to select from the flowing plasma such elements as are required for the elaboration of each particular tissue. In relation to the blood these become true excreting organs, selecting from that fluid particular substances, as if they might be injurious to it or to other parts (Carpenter). In relation to the tissues they are forming they are secreting organs, selecting, forming, and depositing materials for their growth.

In their selective power in appropriating only the proper elements from the plasma as it flows through them they exercise a discrimination that would almost seem impossible independent of conscious volition. It is equalled only by the seeming intelligence displayed in the proper placing of every particle of the constructive elements in tissue-building, and the artistic variations and niceties of shadings in structure-moulding which distinguish character or temperament. But the formative organ must be perfectly normal in structure and tone that it may perform perfect work. Its production must be a perfect copy of the prototype of its kind. Indeed, it should be an advance upon its prototype, that there may be advancement in the development of the species. A copy that is incomplete and abnormal in any of its parts—that is, deficient in any element of structure—is imperfect, and by that imperfection creates a tendency toward atrophy and the ultimate suppression of that organ or part, and thereby perhaps endangers the very life of the species. Perfection is therefore necessary to the perpetuation of organs and the preservation of species. Perfection only comes of normal formative organs and normal nutrition. Imperfection breeds imperfection in the direction either of incompleteness or of weakness or disease.

The disturbing elements of normal nutrition are so numerous and varied that their intelligent study, in even so comparatively limited a field as the formation of the teeth in man, is difficult and formidable. At the outset of this task it will be necessary to classify the immediate causes of imperfect formation to facilitate their further analysis. We will assume, therefore, that deviation from the prototype of an organ, such as a tooth in man, is due, in the first instance, to one or more of the following causes:

(1) Deficient nutrition;
(2) Diseased nutritive fluids;
(3) Imperfect formative organs;
(4) Diseased formative organs.

(1) *Deficient nutrition* is that condition in which the quantity is inadequate to supply the natural demands of growth, the quality being normal. The prime defect is deficiency of quantity, simple starvation. The result is a structure deficient either in form or strength, but which, so far as formed, is of healthful appearance. In the teeth we can perceive how this cause might produce many varieties of the phenomena of defectiveness with which we are familiar. The train of evils which follows in the wake of defective nutrition cannot be definitely tabulated, but we can suggest such as uncalcified enamel, stunted crowns, cusps, or roots, uncalcified dentine, interglobular spaces, far-reaching pulp-horns, large apical foramina, deficient cementum, etc.

All these and more imperfections can be attributed to the cause under consideration. Not that we can distinguish with any approach to certainty between the results of this and any other of the causes of abnormality, but such as those enumerated it would seem might arise from it.

We may note as the origin of this deficiency, first, anæmia or other weakness of the maternal source of nutrition. The mother is too often, by the mere condition of pregnancy, reduced in health and strength to

such an extent as to be unequal to the physiological demands of the fœtus. This arises from inherited weakness and disregard of the means of promoting individual health. Such an one is unfit for the duties of maternity, for she can bring only disease and weakness into the world; but such are often the mothers of the rich and luxurious classes. Indeed, a large proportion of civilized women are physiologically unfit for the duties of maternity.

Another cause of the deficient nutrition of growing organs is the secondary effect of disuse in inducing the suppression of unused organs. This is especially noticeable in man in the case of the wisdom teeth. These are usually atrophied, and they are so frequently totally suppressed as to indicate their ultimate disappearance from the species. This suppression can be accounted for only by lessened nutrition through the workings of the law of economy of growth. The teeth of all civilized men seem to be suffering from lessened nutrition owing to disuse. Much of the inherent weakness and defectiveness of structure, and also the rudimentary forms often presented, or even their occasional or total absence, arises from this cause.

(2) *Diseased Nutritive Fluids.*—This branch of the subject leads into the larger field of the modifying influences of disease upon dental development, which will be noticed hereafter. It includes the whole list of transmissible diseases which prevent nutrition and render the constructive pabulum impure and poisonous. Diseased plasma is due primarily to diseased assimilative organs incapable of presenting wholesome food to the blood, passing it either imperfectly digested or otherwise vitiated in character. Diseased excretory organs fail of performing their normal functions of eliminating from the blood the poisonous products of natural waste of the tissues, and these are added as deleterious elements to fluids perhaps already vitiated by the poisonous principles of the disease itself. When all these possible sources of impurity are considered, the wonder is not that the teeth are diseased and imperfect, but rather that they are developed at all.

It illustrates the inherent force of the creative instinct in the tissues that the organ should attempt to build with imperfect and diseased material. Failing of obtaining pure pabulum, it will build of that which lies at hand, for it must obey the constructive impulse.

(3) *Imperfect Formative Organs.*—This part of our subject takes us again into the domain of evolution. The laws of development could be made to account for defective organs in process of suppression. Disuse would, as a step in the process, cause atrophy of the formative organ, either symmetrical or asymmetrical. As the teeth in man are in course of suppression on account of disuse, in accordance with well-known laws, we can readily conceive of nature employing this element in the work. The reduction of organs to be suppressed—as, for instance, the teeth—could be effected in this way by the reduction first of the formative organ. As we contemplate the many forms of malformation exhibited by the wisdom teeth, we are led to account for their occurrence and for the frequent absence of these teeth by their formative organs being incomplete or totally suppressed in man. As other teeth

are often absent or malformed, we have reason to believe that they also are under the influence of this law.

Then, again, mere accident will often account for imperfect, asymmetrical, or deformed formative organs, just as accident causes deformity in other parts. This may give rise to teeth which are asymmetrical, contracted, or stunted, or mechanically incomplete in any respect, but when such defects become hereditary, as they are prone to do, they pass from the domain of accident to that of law, and must be studied from that standpoint.

(4) *Diseased Formative Organs.*—Disease will occasion imperfect formative organs, and by that means cause defects in the teeth and be a fruitful source of many of the abnormalities with which we are familiar. The diseases which apparently most readily impress these organs are the eruptive (exanthematous), which affect the derm and its products and related parts. They appear to cause eruptions and derangements of greater or less degree of all this family of tissues, and the dental follicle does not escape. Perhaps the pits and ulcer-like marks in the enamel of defective teeth may represent ulcerous points upon the follicle where formation was impeded. The exact relations between pits in the enamel and eruptive diseases in infancy have often been traced. Such defects arise most frequently, indeed, from diseases affecting the tissues evolved from the epiblastic layer of the embryo, which are intimately connected in origin and relationship and maintain close sympathies. This great family of tissues is so comprehensive in its anatomical and physiological importance to the economy, so interdependent and sympathetic, so sensitive to pathological disturbance and predisposition to disease, that we cannot be surprised that the hypersensitive tooth-germ frequently partakes of the diseases affecting any of its various members. The teeth are also related to the nervous system in origin and sympathy, and therefore many nervous disturbances affect the tooth-germ and derange its functions.

Having noticed the physiological *methods* by which aberrations of nutrition or function may affect the growth of the developing tooth, we come next to the study of the extraneous *causes* of such disturbances—the causes which influence either the nutritive fluids or the formative organs, or both, to the disadvantage of the forming tooth, occasioning its imperfection.

For convenience of study we will classify the main causes of congenital dental imperfections as follows:

INFLUENCES MODIFYING THE DEVELOPMENT OF THE TEETH.

(1) Heredity;
(2) Miscegenation;
(3) Civilization;
(4) Food;
(5) Nervous disturbances;
(6) Disease;
(7) Drugs and artificial diseases.

(1) Heredity.

Man moves within a narrow sphere, bounded by the physical possibilities and psychical impulses inherited from his ancestors. He is the epitome of the experience of his predecessors: he inherits from them the possibilities of life, the organs best suited for maintaining that life, and the power to transmit life and impulse to succeeding generations.

But he does not transmit form and substance and impulse unimpaired and without variation. The individual experience is constantly exerting a pressure, in one or another direction, upon every organ, according as it is used or disused, which tends toward its modification. "When a new character arises, whatever its nature may be, it generally tends to be inherited" (Darwin). Variations are readily created and as readily transmitted, thus showing the flexibility of vital organisms. They generally arise for the benefit of the individual—for adaptation to a new environment, for instance—but even if injurious are often passed onward. As environments are ever variable, change is ever occurring, and an organ is never transmitted in precisely the same condition or form in which it was received. In man variation is now under the domination of the artificial life by which he has surrounded himself. He is far removed from a state of nature, and as a result which might be expected the variations at present in progress in his structure rather tend to the degradation and deterioration of his physical organization. This is especially noticeable in the tendency to transmit imperfection and disease. Mr. Darwin has noted at length the frequency of the inheritance of disease and malformation, as have also other observers and writers. But in no other class of organs is the effect of inheritance by variation due to the influence of changed conditions so marked as in the teeth of man. Being so peculiarly susceptible to the influences of use, they have, by the protracted effects of disuse retarding their development for generations, become so deficient and incomplete in form and structure as to approach the condition of rudimentary organs. The wisdom tooth especially is in a rudimentary condition in civilized man, and is hastening toward extinction.

But through the law of inheritance the teeth are the unfortunate recipients of a legacy of disease in many forms, the tendency of which is to intensify in the course of transmission.

With many diseases of other organs there is a real tendency to spontaneous cure by the gradual lessening and elimination of the disease during transmission, but each succeeding generation has weaker and more defective teeth than that which preceded it. The irresistible forces of heredity thus supplement the destructive effects of disease by the workings of reduced nutrition and the creation of a predisposition to their attacks.

Not only is the type of tooth usually determined by the impress of one or other of the parents, but its particular defects are the result of parental impression. Especially is this the case when there are unfortunate temperamental or consanguineous combinations. Of course, the immediate effects are not all that are to be considered, yet they are often

paramount to the influences of remote inheritance. Special defects are usually traceable to recent hereditary origin.

"The influence of parents on the constitution of offspring is something manifested not merely in the mixture of their characters normally displayed, but also in the tendency to the transmission of perverted modes of nutrition which may have been habitual to either parent. Many diseases are recognized as hereditary, and perhaps others might be added to the list. A predisposition may have been congenital on the part of the parents, or it may have been acquired by them and transmitted" (Carpenter), as witness the transmitted effects of syphilis, gout, phthisis, insanity, alcoholism, etc. Again: "The intensification which almost any kind of perversion of nutrition derives from being common to *both* parents is most remarkably evinced by the lamentable results which too frequently accrue from the marriage of individuals nearly related to each other and partaking of the same 'taint'." Aside from "taint," a strong idiosyncrasy frequently presents which, by being intensified, either by consanguinity or idiosyncratic resemblance of parents, may give rise to physical or mental defects, or persons unrelated may possess similar "taints" of disease or organic defects or predispositions to abnormalities, which are increased by the double transmission.

Regarding the effects of heredity upon the teeth and their environments there is no better authority than Dr. Norman W. Kingsley, who says: "Many of the forms of irregularities of the teeth are directly traceable to inheritance, and are transmitted peculiarities. Especially when it is confined to one or two teeth, the primary cause, so far as that individual is concerned, is an hereditary family peculiarity. The teeth of every person possess more or less of individuality, and most of those features which stamp their individuality are inherited. The form and color of the teeth, when not disturbed by abnormal influences, are derived from this source. Any departure from typal forms is a peculiarity of descent as well as a predisposition to defect or deformity. It is a most wonderful subject for contemplation that at some remote period in the history of our progenitors nature departed from the normal type to produce a dwarfed lateral or a twisted canine or to suppress a bicuspid; and, following down the line of descent, we find precisely the same peculiarity appearing and reappearing, perhaps not in the same line, but in the same family. Defects of structure as well as of form and arrangement are also transmitted directly." Thus we know that children frequently have the same defects upon the same teeth which a parent had, and that these teeth become carious and are lost at the same age, or, indeed, sooner, owing to the increased ratio of deficiency by inheritance. A minute defect of contour, a supplemental cusp, a lingual fold upon the incisors, a total suppression of a tooth (as a lateral or third molar), the appearance of caries in the same locations, dark and uncalcified spots, everted laterals or centrals,—all of these, and more, are often traced through families.

A recent writer (Dr. B. Lincoln Ray) says: "Two great powers or laws of nature co-operate in the propagation of a species. One of these laws produces difference, diversity, individuality, by which no two beings are precisely alike. The other great law produces similarity, likeness, uni-

formity, and it has two kingdoms or fields of action—first, in the species, in which it is the supreme and only ruler; second, in the individual, in which it shares its sovereignty with the first-named law. The first is the law of diversity, the second is the law of uniformity or heritage. The law of hereditary transmission is identical with the great law which preserves the immutability of species. The difference is in the scope, not in the nature, of the law. In its first field of action it transmits inevitably specific traits; in the second, it transmits, not inevitably, individual traits." He concludes, "First, that from healthy and unconsanguineous ancestors proceed a posterity of which a very large proportion are born perfect, sound, and with tendencies toward healthy development and healthy procreation; second, that from unhealthy or consanguineous ancestors proceed a posterity of which a very much less proportion will be perfect, etc. Or, to make the correlative statement, healthy and unrelated ancestors produce a posterity of which a very small proportion are imperfect or unsound, while unhealthy or related ancestors are followed by those of whom a very much larger proportion are imperfect or unsound."

Another influence enters into the modification of heredity—viz. that of sex. Dr. W. Sedgwick writes that "sexual limitations, although met with in all forms of hereditary disease, are more constant and strongly defined in those diseases affecting hereditarily the skin and its dependencies than in those affecting the other organs and tissues of the body. And this should not be surprising when we consider that sex modifies the structures in man as in the lower animals; as instance the absence of the beard in woman, the texture of the skin, etc., or in animals notice the difference in the plumage of birds, the spurs and comb of the cock, the weapon of the male of many species, etc. Correlative abnormalities of related dermal structures are often confined to one sex. Peculiar malformations of the teeth or their irregularities often follow the male or female lines exclusively, or occur as marked cases of atavism in the same sex. Sometimes the tendency to caries and other dental diseases is confined to one sex. Hare-lip has also been noticed, when hereditary, as being so limited, and is often accompanied by special defects of the eye and of the teeth. It also occurs according to the law of atavism."

The writer does not agree with the above in its entirety, but believes, on the contrary, that one great law of immediate descent is that, as a rule, the child inherits its physical peculiarities, temperament, size, structure, organic peculiarities, etc. from the parent of the opposite sex. Thus, the daughters are most likely to resemble the father, and the sons the mother, and the teeth are often influenced by this law. The rule is not exact, of course, but there will be found few exceptions to it. If the child does not resemble the parent of the opposite sex, it will often be found to resemble that parent's ancestors. Thus, if a son does not resemble his mother, he will be like her father or *his* mother. It is interesting to trace these resemblances in families, and to note with what exactness the rule of the reversal of sexes in inheritance holds out.

The reappearance of types—what is called atavism—is but the manifestation of this law, where a peculiarity skips several generations to

reappear when it is, perhaps, quite forgotten. The persistence of type in reproducing itself is one of the wonders of heredity. In the case of the teeth this is most fortunate perhaps, for it allows for the reappearance of a good denture in a family with defective teeth, with a prospect of its immediate transmission and the improvement of the family type; but, by the same rule, it unfortunately permits the reappearance of a denture particularly defective in a family which has good teeth, with a chance of its perpetuation. Sometimes there is blending of the types of two or more ancestors, the front teeth presenting the good organization of one, and the molars the diseased structure of another, or *vice versâ*. Atavism is a mystery and has its freaks and fancies, but it nearly always works through the system of a reversal of sexes. Disease, deformity, and defectiveness are prone to disappear and reappear, but in compensation for this health and strength are subject to the same law.

An apt illustration of the powers of heredity and the precision of its impressions is furnished in the case of twins. Here are two beings created at the same or nearly the same instant of time which are identical in physical and mental characteristics. Coming into existence under the same conditions and influences, and being subjected to the variations of these conditions and influences at the same instants during their intra-uterine life, it is not surprising that the two beings are similar in feature and structure. The mutual impressions there received, the same elements of nutrition, the same variations of health, the peculiarities of diseased conditions, the influences of maternal emotion, of paternal impurity,—every variety is photographed with startling similarity upon the two embryos, which are as nearly alike as it is possible for any two beings to be. Two individuals of any species of animals are never so nearly identical under any other circumstances—a fact which aptly illustrates the power and versatility of heredity, in that a given combination of conditions never occurs twice precisely the same. When we grasp this stupendous fact, we do not wonder at the infinite variety displayed in the features of the members of our own species. Two individuals are never exactly similarly gifted in regard to any one physical or mental quality. The endowment of any one in any direction is certain to differ from the same quality in every other person.

But even twins often present slight differences, showing that conception took place in the two ova at two different instants of time when the conditions were slightly different. Changes occur with such rapidity that even the brief period between the presentation of two ova could make a difference in the features of the individuals formed which are perceptible to our imperfect senses. What vast possibilities of variety does the creative power possess that an instant of time can make variation! It is small wonder that no two individuals of any species, no parts of these individuals, no two leaves, no two buds, no two hairs, no two cells, are precisely alike. In diversity, however, there is resemblance that makes identity: while parts differ, they are yet sufficiently alike to make classification possible, and that resemblance is irresistibly transmissible. The flexibility within a small compass is wonderful. The capacity for variation is incomprehensible.

M. Topinard says:[1] "The law of inheritance is that the son is the reproduction of his father and mother. Among the inscrutable influences which cause the child to put on special characters there is a conflict of all the elements which figure in his genealogy. He resembles his mother during a portion of his existence; at a later period he becomes like his father, and anon like a distant relative. In every individual or in every generation of individuals there are two opposite tendencies, the one to divergence or variability of characters, the other to concentration or perpetuation of characters. The force presiding over the latter is inheritance, the disposition of living beings to reproduce themselves under the same forms and with the same attributes. There is a constant struggle between characters: while some are augmented, others are neutralized, and others have a reciprocal influence. The most remote ancestors have their share in the results as well as the nearest relatives. In atavism the reappearance of characters is a matter of chance, or, rather, there is the germ of latent influences which it is impossible to fathom. Certain characters retain their hold more firmly than others. In the law of inheritance there is nothing of an occult kind. Here like merely begets like.

"The following are the principal forms of inheritance: (*a*) *Continuous* inheritance, when the son resembles his parents, and these their parents. (*b*) *Interrupted* inheritance, when, without resembling either father or mother, he is like a grandparent; this is very remarkable as regards the transmission of disease, which frequently alternates. (*c*) *Collateral* inheritance, when a child resembles an uncle or granduncle. (*d*) *Atavic* inheritance, when the resemblance goes back still farther."

From these suggestions we conclude that heredity is a power of stupendous influence, and exerts a modifying effect upon the quality of the teeth that is paramount to everything else. But, after all, it is only an agent in passing effects onward; it is not a *cause* of defective teeth. All the investigation possible would not demonstrate that heredity *per se* was a cause of deficiency in dental structures; for heredity is but a physiological force that creates beings in imitation of those from which they spring. The causes modifying the qualities of the tissues is a different matter. These direct and order, while heredity executes according to law and with scrupulous and often merciless accuracy of obedience.

(2) Miscegenation.

The mixture of the different races of man is so important a cause of physical degeneracy as to demand special consideration when discussing the causes of the imperfections of the dental organs. It is, in some sense, a continuation of the subject of heredity, for the power of inheritance makes the permanence of racial characteristics possible.

The persistence of the qualities of race is one of the wonders of heredity. Many races exist to-day which have continued unchanged for centuries, as witness the Egyptians, whose physiognomies, as depicted on the monuments of thousands of years ago, are the same as the pure

[1] *Anthropology.*

Egyptian stock of to-day. The Jews also, whose religion has prevented intermarriage with other peoples, have preserved unchanged their racial characteristics for thousands of years. Numerous instances of this kind are related. M. Topinard shows that "from inheritance emanates the law of permanence of type. In the pure race all the individuals resemble each other as regards their main features. The characters which mongrels exhibit are only applications of the law of inheritance, the consequences of which are reduced to a calculus of probability. Sometimes the mongrel of the first blood is exactly intermediate between the parents in color of skin, character of hair, or proportion of skeleton. Sometimes the mongrel embodies a portion of the characters of one or both parents. Some children are exactly like the father; others, again, like the mother. . . . . Examples of interrupted, collateral, and atavic inheritance are numerous among mixed breeds. The peculiarities of one or the other race are apt to be retained.

"It is often asked if crossing produces an improvement or deterioration of races, and whether it ought to be encouraged. External conditions must be considered, and these have been too much overlooked: when considering racial vitality acclimation is lost sight of. The majority of the examples we have are favorable to crossing, but opinions differ. One ethnologist attributes to crossing the disasters of empires and the degradation of races; another claims that if it were general it would lead to the extinction of peoples; another, that civilization could not make progress except with pure races—that the pure races are superior in equal struggle; and many others, that the era of universal peace and fraternity will be realized by crossing. Two pure races will have a better progeny, two impure races a worse progeny. Two races, the one pure and the other impure, will have a progeny impure relatively to the superior race, and pure relatively to the inferior. The law of inheritance is exerted with rigid exactness, but a multitude of other conditions are mingled with it which cannot be ignored, the action of external circumstances, acclimation, morals, education, social customs, etc."

Again he says: "All the peoples of Europe are the resultants of a series of crossings. M. Broca found that most of the population of France presented in various degrees the characteristics of mixed races. Thus, the Bretons are one-fourth Cymrian and three-fourths Celtic, without including other elements. After the Revolution the victors and vanquished intermarried, improving in fertility, and thus increasing the population. Everywhere throughout Europe two elements must be taken into account, the fair and dark, which are promiscuously intermingled. The prosperity of the new American race is a favorable example of crossing. Immigration into the United States has been enormous, and every variety of cross has been going on between the English, Irish, German, and Latin races, with the greatest possible success. The Spanish people have a large intermixture of Moorish blood, but the Moors themselves are a medley of races, with Arab and Berber predominating. Even in Asia Minor mixing is extensive, and in Larger Asia it has gone on for centuries, with more or less local exception where comparatively pure races, not of recent traceable intermixture, may be found.

"One of the first effects of the inability to become acclimated is diminished fertility; the germ seems to be attacked in its very earliest inception." If one race is indigenous, this rule does not obtain, as the progeny are then fertile, as witness the Indian crosses in America, the Eurasians of India, and half-breeds nearly everywhere. "Formerly, when seas and forests caused mankind to be more isolated, the accidental characters in race were confined and their aspect remained unchanged. Now that emigration has assumed such vast proportions the characters are less distinct. Crossing is the principal agent in the heterogeneity of races, as hereditary influence and external circumstances are the principal agents in their segregation and isolation. The one will introduce unity in the future, the others must have produced plurality in the past."

With this exposition of the facts of crossing, its methods and influences, we will consider its effects upon the teeth of man.

That the crossing of different and various races, and the mixture of these crosses in various degrees and proportions, should have a direct effect upon the teeth is at once reasonable and demonstrable. Nature makes an effort to fuse more or less discordant as well as harmonious elements with more or less success, as instance the unfortunate results in the combination of large teeth and small jaws of distinct races. Dr. J. H. McQuillen was one of the first to call attention to this fact. He says: "A prolific source of this combination of diminished jaw with large teeth in our country is the constant blending of types caused by the intermarriage of different nationalities: the variation in the size and form of the teeth and maxillæ in those nationalities produce in their offspring irregularities of the most marked character."

Of this Dr. Norman W. Kingsley writes at length, and of the influence of race-mixture being a well-established and familiar fact: "The blending of a broad jaw like the North German with a narrow tooth, or, again, a broad tooth with a narrow arch, leads to deformities of various kinds with which we are familiar. Aside from accidental variation due to disease or imperfect development, most of the abnormalities of arrangement are to be charged to the crossing of races, especially as found in America, more particularly in the Anglo-Saxon population of the United States. The persistence of race, the reappearance of extreme racial qualities erratically in all possible and unfortunate combinations, all contribute toward the degradation of the teeth and their surroundings. Perhaps happy combinations sometimes occur, but these are exceptions and not the rule. Mixture does not tend toward the perpetuation of the best qualities of races, and even if it did their combination would ofttimes produce excess and disadvantage. Racial peculiarities are continually, by the law of inheritance, struggling for predominance, and where two or more races are combined in the same individual there is a conflict which cannot contribute to his advantage. The result is a depression and degeneracy of the physical organization or its asymmetrical development, with its necessary effect upon the teeth."

Dr. E. Magitot has dealt with this subject in his studies on dental caries, and given us as precise data as can be found anywhere. He says:

"It is notorious that in certain families and in certain races caries is a frequent and habitual malady through the transmission of certain anatomical predispositions of structure. Certain circumstances of form, of color, of intimate organization, constitute ethnological characteristics. Thus, vicious dispositions of dentition or anomalies of structure reproduce themselves through successive generations. In Normandy, for instance, we believe that the prevalence of caries is to be attributed to a faulty internal construction of the teeth so general as to constitute a true race characteristic. The mixed races seem more disposed to caries than those which have remained pure or comparatively so; and this is also the case with those which have been transplanted away from their native soil, or with their descendants where acclimatization has been difficult."

By means of the official registration of examinations of military recruits in France he compiled statistics from which he was enabled to prepare a scheme of the prevalence and the geographical distribution of caries in France. He gives a map in his work on dental caries which shows this distribution. He found that the "minima of prevalence formed two groups, one consisting of the greater part of Brittany, and the other occupying the central plateau of France and prolonged toward the Mediterranean, following the Rhone. The maxima are found solely in the departments of ancient Normandy, etc. We notice that the best preserved vestiges of the two principal races that have peopled our soil are represented by the tints regarding the prevalence of caries. Thus, the Celtic race included in the region of Brittany is marked in white, the minimum; the other white region is corespondent with an agglomeration of Gallic peoples, a central Celtic region. On the other hand, if we regard the black trail crossing France from the north-east to the south-west, we find that this direction is precisely that followed by the Cymric invasion which entered Gaul about the seventh century B. C. and left such lasting traces. Some Cymric groups quite pure are still found along this trail. We conclude that the population of France is divided in a general way in regard to dental caries into two great families: the Celtic family, with small and stocky individuals, has a hardy dentition, and the Cymric family, with large blonde individuals, has a dental organization which is defective. We think that account should be taken of questions of race in this matter, still more than of soil, climate, surroundings, habits, or social life."

The direct evidence which by his praiseworthy investigations M. Magitot brings to bear upon the subject of miscegenation as a cause of dental caries, cannot be disregarded. He shows, by the plain argument of statistics arranged in chart form, that his reasoning is conclusive.

In the consideration of this question here we have only to do with abnormalities produced by mixture of types. It is true, of course, that while heredity is a means of propagating and perpetuating defects, it is also a power for good in correcting vitiated constitutions by crossing with purer and stronger blood; and this is supplemented by the effort nature continually makes, by a sort of instinct of self-preservation, to eliminate disease and vicious humors. But the commingling of heterogeneous types is a great cause of abnormalities in this connection. Dr. McQuillen's doctrine of the crossing of wide teeth with

narrow jaws illustrates inharmony of types and consequent deformity arising from bad selection in marriage, whereby the wrong strains were crossed. There may be homogeneity of types, and the result be normal and unnoticeable, all the elements being harmonious, but with this side of the question we have nothing to do.

The law of the principle may be briefly stated thus: *Inharmony of racial characteristics in crossing is an active cause of dental deformity and defectiveness.* Where one strain is weak and impure, of course the offspring will be still more depressed, in addition to inharmony. The first effect of crossing, when inharmonious, is depressed vitality; the next is confusion of types and deformity, either as to form or as to structure; next, defectiveness as a consequence of the effort to harmonize; and lastly, the impress upon the too-susceptible tooth-germs of a physical degeneracy which has become hereditary. Heredity is so powerful a force that the crossing and counteracting influences that preside over growth and development cannot always guide the conflicting tendencies of race to an harmonious result. Like powerful forces pulling or pushing in opposite directions, their combined attractions and repulsions must unavoidably produce imperfect results; and, as these are the rule in dental organizations, most of them may be due to miscegenation. Many writers claim that fertility is increased and the perpetuation of the species guaranteed by crossing; but that very fertility is at the expense of vitality and physical strength, for the result is a hybrid, and hybrid races are weak. The pure races are always the best in physical strength, development, and endurance. Purity of blood is strength, mixture is weakness. Crossing depresses vitality and physical health, leading to imperfect performance of the functions, with a deleterious effect on the development of the fœtus and also the derangement of the evoluion of the teeth.

The application of these studies of race to the people of the United States will at once suggest itself. Here is a people of ideal heterogeneity—a nation of infinity of racial mixture. In them flows the blood of the Anglo-Saxon, the Teuton, the Celt, the Gaul, the Scandinavian, and the Latin races of Europe in all their native varieties and foreign intermixtures. In addition to these there is a large mixture of negro blood and of the various native Indian races. The Mongolian and the Aleut, although within our borders, do not yet cut any figure in crossing, as may also be said of the accidental presence of other races. The Indian is crossed with the white races in the United States only locally, and the hybrids constitute relatively but a small proportion of the people. Indian blood has no effect upon the population at large, and is not nearly so important an element here as in the population of Canada. In this country the mixture is confined to the Indian reservations and the neighboring regions. The teeth of these half-breeds vary in quality, and are relatively good as they resemble their Indian ancestors, or relatively bad as they resemble their white progenitors. Too often, however, they are tainted by the vices inherited from their Anglo-Saxon sires (frequently of the lowest moral grade), and their teeth are correspondingly defective. Honest intermarriage with healthy whites often occurs, the issue of which have good organizations and good teeth.

With healthy progenitors on both sides the Indian cross is a good one.

The mental superiority of the white race manifests itself in the proportionate superior intelligence of the half-breeds over their Indian relatives, but physically they are inferior to them, although often better than their white relatives.

The ethnological problem of the ultimate effect of the total absorption of the negro race in the United States is a most serious one. Its effect upon population at large does not yet amount to much, but general absorption by the white laboring classes of the South and West, such as is going on, cannot be without momentous results. The destiny of the negro in this nation is absorption by intermarriage with the white race. As race prejudice dies out intermarriage will become more frequent. Even now the union of negro men and white women in the South-west is not uncommon. As the negro blood is far from pure, and as the whites with whom they chiefly intermarry are of the vicious and impure classes, this miscegenation is an unmixed evil. Even the mongrels who come down to us from slavery days, and who are the result of crossing with comparatively pure white blood, are a degenerate people. So we conclude that the crossing of the negroes and whites is not for good, and this is demonstrated by the physical and moral degeneracy of the hybrids resulting from the combination. Regarding their dental organization, it is of the worst. The American negro race is saturated with scrofula, with which every individual is more or less tainted, and this, crossed with the weakness of the white races, does not contribute to good dental organization. Very few mulattoes are found who possess good teeth; many of the pure negroes do, however. One cause of their degeneracy may be found in the fact that, like the white races, they too are a foreign race in a strange land, not yet acclimated and harmonious with their environments. With no influx of pure blood flowing into their veins from the native land of the blacks, degeneration and absorption is their destiny. As the negro blood becomes weakened and attenuated by further mixture with the superior white blood, the racial features gradually disappear, the last trace to vacate being a constitutional pulmonary weakness.

Spanish, Italian, and French blood, or that of the Latin races, so called, has been mainly of local influence in this nation; but having been of some duration in these places, it affords material for profitable study when these examples shall have been properly investigated. The French have crossed with the native Indian races in the extreme North with considerable success, both as to physical and moral results. In the South, where the French blood has been mixed with the Indian and negro, the offspring have not been so healthy and the dental organization is particularly bad. The Spanish blood mixed with the Indian races of the far South-west has produced the best results of any European race crossing with the indigenous population. Centuries of acclimation have of course done much for the perfecting of the physique of the descendants of the conquerors. The mixtures of Italian blood we cannot trace, nor, indeed, can we trace the line of the descent of any of the Latin races in our population, yet many of the finely-arched jaws and

small, shapely teeth so frequently met with must be assigned to such ancestry. When healthy, the Latin blood is not disadvantageous to the dental structures. But the bulk of the population of the United States is of English, Irish, and Teutonic lineages, none of which seem to conduce to good dental organizations, and any of which, when intermingled, are productive of multiplied abnormalities of structure and form. The impure lineage and the weakness produced by these crossings and mixtures have left their marks upon the teeth of Americans. The Scandinavian blood, recently introduced in large quantities into the North-west, contributes no strength, but rather weakness, to the general stock. Some of these races, as the Swedes, come to us with imperfect dentures and weak tissues due to constitutional scrofula, with which many of them are affected.

And here we must consider that climate is an element in this question which cannot be ignored. German, English, and Irish who have been in America but a few years all experience rapid deterioration in their dental structures, leading to destructive caries or abrasion which did not afflict them at home. This deteriorated condition is at once transmitted and passed on into the general population. This is a source of much of our dental degeneracy which has not been properly estimated. The degeneration is immediate in the individual on leaving his native soil and settling here. Change of climate, air, soil, habits, food, etc. all contribute in greater or less degree. These things cause a depression of the vital forces which adds its influence to that of race-mixture. In time, perhaps, perfect acclimation will take place and a better physique be developed in the United States.

Old families in various parts of the country which have resided uninterruptedly in the same localities for several generations could furnish some important evidence in this connection. Climate modifies indefinitely, and creates out of the old races new ones which are distinct and individual. It is as potent in evolving new types as fusion itself. All distinct types were originally of hybrid origin, but by permanence they have become fixed and hereditarily transmissible, with persistent racial features. In this transformation climate is the principal factor. In the United States this work is in progress to-day. The fusion of different races and the different varieties of races, supplemented by the modifying influence of climate, is rapidly evolving new types. In time perfect acclimation will be accomplished in the descendants of the Indo-Europeans in America, and new races will be formed. The interminable movement of people within our own borders will defer the development of the ultimate type, but it will arrive in time. Every locality will have a distinct type of its stationary classes, while above that will be a type distinctive of the whole country as characteristically American on account of its national prevalence. As these types become formulated and the synthetic work accomplished, the standard of physique will be elevated, and with it the quality of the dental tissues. The acclimated American of the ultimate type will have good teeth.

We cannot conclude this department better than by quoting from Dr. James Truman, who has written upon this subject with especial clearness. He says: "This blending and clashing of individual or race

peculiarities may affect the entire machinery of life or any part of it for good or evil; it may impair the nutrient functions and cause the teeth to be defective; it may impair the nerve-functions and lead to irregular dentures. When several distinct races have been thrown together, in course of time they become so blended as to really form new types, and these in turn by the same process form other types possessing peculiarities as marked and distinct, though not so sharply defined, as those distinguishing the original races. This may be noticed in some of the older nations, England for example. The modern Englishman is so perfect a blending of all the various races from which he sprang that his identity is lost; the marked peculiarities of all are retained and harmonized. The same process is going on in our own country, and, while it may produce temporary disturbances, we have no expectation that the coming typical American will be any more different from the present mixed ancestors than the Englishman is different from his Saxon, Danish, and Norman progenitors."

The points which we wish to insist upon are, that the fusion of fixed types has (1) a depressing effect upon the vitality, and therefore causes a deteriorated condition of the dental tissues, which are especially susceptible; (2) that the crossing of types causes deformity; and (3) that nervous inharmony induces degeneration. But the scientific study of the subject is as new as the science of anthropology itself, and its complete elucidation must await the accumulation of sufficient data, which are at present very meagre.

(3) Civilization.

Civilization as a factor in the list of accepted causes of dental degeneracy was much discussed by the writers and theorists of the previous generation, and was generally believed to be a principal source of this degeneracy. It was held on all hands that the evils arising from defective teeth were mainly, if not entirely, due to the artificial and unnatural mode of life of civilized man, and the theory came to be known as the "artificial-mode-of-life" theory. The remedy, it was claimed, for the present deplorable condition of the teeth, therefore, was a return to more simple and savage ways of living. The extensive discussion and general acceptance of the theory naturally led to investigation of the phenomena of savage and natural modes of life, in order that the theory might be verified and valuable lessons learned therefrom. So the tombs and sepulchres of ancient races and extinct peoples were searched, and collections of skulls were examined, and the classical writers of antiquity interrogated, as well as the later investigators of, and writers upon, the antiquities and ethnology of prehistoric and primitive races. In addition to this, investigations were carried on amongst contemporary savage peoples in all quarters of the world. The results are a mass of material containing more or less evidence confirmatory of the theory, and more or less that refutes it. The investigators showed that, as a rule, defective dental organization and diseased teeth were coincident with and proportional to the degree of civilization. But notable exceptions were found to the rule in cases of the peoples who, with a high degree of civ-

ilization, had fine teeth, as the ancient Greeks and Romans, or who, in the lowest scale of savagery, like the recent Bushmen and Australians, suffered from all the diseases which dental "flesh is heir to." But yet, again, the teeth of the Greeks and Romans of later times, after the pinnacle of their greatness had been passed and their manhood sapped, their fine physical organizations undermined by luxury, effeminacy, vice, and indolence, partook of the general depravity and were poor and diseased. The results of these extensive investigations demonstrate what has come to be known from other sources, that the strength and perfection of the dental tissues are directly proportioned to the physical vigor, strength, and vitality of a people, and that as their physique is, so are their teeth. Still, the civilization theory is a good working hypothesis, and through it many valuable truths have been learned and important lessons have been taught.

One of the most complete and comprehensive reports upon the comparative condition of the teeth in the various races of man was that of Mr. J. R. Mummery, made to the Odontological Society of Great Britain in 1870. He showed that the ancient dolichocephalic race of Britain of the Stone Period—a pastoral people—had little or no caries. These were driven out or enslaved by an invading race of Belgio-Celts, who were brachycephalic, agricultural, and more civilized, and who had more dental diseases, exhibiting a marked contrast thus early in the ethnological history of Britain.

With the Roman conquest a great change took place: with the civilization then introduced came luxury and physical deterioration. The subjugated Britons, adopting the habits of their conquerors, became effeminate and much dental disease prevailed. The Romans of that period were of course much affected with dental disease. After the Romans withdrew the Picts and Scots ravaged the West, the enervated Britons being unable to stand against them. In alarm they called in their German relatives to help them, and the Angles and Saxons came, and came to stay. Now, it is observed that these invaders, all being of a more robust and vigorous constitution than the luxury-loving Britons, brought with them an improved condition of the dental organs, which was impressed upon the population, and the average at once toned up. Then other waves of barbarians swept southward, each one bringing improvement in the dental constitution, which deteriorated after fusion with the conquered peoples and the adoption of a sedentary, civilized life. The facts thus presented by Mr. Mummery are very valuable.

In the skulls of ancient Egyptians comparatively little dental disease is found: those of later civilizations, however, exhibit more disease, in conformity to the rule that as a people become luxurious and effeminate and their physical organization deteriorates, the teeth also are affected in proportion to the ratio of their physical degeneracy. But the slaves of this later period, coming of a hardier race, exhibit less dental disease than their masters.

The Zulu Caffres of South Africa are a fine race of people, possessing great intelligence and some civilization, and they have fine teeth. Their more savage and depraved neighbors, living precariously and being of

poor physique, have poor teeth. High-caste people in India, living strictly but well, have rather poor teeth, while the lower castes, when of good physique, have fine teeth. In China dental disease is proportional to the quality of physical development as influenced by habits of life, whether luxurious or plain.

And so the evidence as furnished by these investigations amongst all peoples in all ages, so far as presented, tends only toward showing that dental disease, following upon deterioration of the dental tissues, is directly proportioned to the degree of physical depravity of a people, from whatever cause. The position of a people in the scale of civilization has nothing to do with it, but their physical vigor and vitality have. A civilized people may be vigorous and strong, and as a consequence they will have good teeth; a savage people may be weak and depraved, and, naturally following this condition, the teeth will also be weak and poor. But civilized people who continue civilized are certain, in time, to deteriorate physically, owing to the luxurious habits and vices they acquire as the natural result of possessing wealth and leisure. This is the price of civilization. The savage, on the other hand, being forced to a life of activity by the struggle for existence, is far more likely to possess a fine physique as a result of this activity, and as a consequence to possess good teeth.

The aggressive advocates of the "artificial-mode-of-life" theory placed most stress upon the unnaturalness of the diet of civilized man, which does not provide the necessary ingredients for the construction of good teeth, and is therefore the main cause of dental deterioration in civilization. But the very variable diet of savage peoples in different parts of the world proves that one particular diet is not essential to good teeth. So that the food, whether vegetable or animal, contains the elements of structure and is wholesome and sufficient, it does not matter whether it is whale-blubber, raw cocoanut, or human flesh, salmon or jerked beef. The special preparation of foods in civilized life goes for nothing, provided that food is sufficient. Savage food, *per se*, is no better for the making of teeth than civilized food; but when we come to the effect of civilized methods of preparing food as inducing disuse of the teeth and their consequent deterioration, we find a far more potent source of evil.

The teeth suffer directly from the effects of disuse, in that they and their supporting environments are deprived of the stimulus of healthful employment necessary to their thorough nutrition and the maintenance of normal solidity and strength and the excitation of a normal vitality. From the lack of the stimulus of constant use they are deprived of a normal condition of health as a direct effect. But another and fully as serious an effect of disuse is the transmission of lessened demand for the development of the teeth, which, working through the law of economy of growth, tends toward lessened production of the teeth either in quantity or quality. We believe that this law is operating in civilized man at present, and that his teeth are being gradually suppressed, owing to this effect.

Another law that works to the disadvantage of civilized man is that of the survival of the fittest. Interference with the working of that

law does much to deteriorate the civilized races. In savage life it is only the strong, the fittest, who survive in the individual, hand-to-hand struggle with nature, and who propagate the species. The weak go to wall and do not multiply, and an unconscious selection is thus going on for the benefit of the race. But in civilized life the law of mutual assistance and dependence prevails, and the weak and diseased are tenderly cared for and preserved to propagate their kind, to multiply weakness, deformity, and disease, and pollute the entire race. Of course, with our humanitarian ideas it is not possible to do otherwise, except that the marriage of unfit persons might be prevented without much hardship to the individuals themselves and with great benefit to the human race at large. But the disagreeable fact remains that charity and benevolence are doing much to degrade and destroy the whole race by the preservation of the unfit and their unrestrained propagation. Witness the increase in lunacy, in blindness, in the number of the deaf and dumb, and in deformity by the transmission of disease and defects. It is a question if our humanitarianism is not inhuman. The influence of this contstant influx of impure blood is not, of course, without its effect upon the teeth, which cannot be perfect when grown amid disease. Without the constant tendency to elimination manifested by nature man would soon become extinct before the accumulated effects of cultivated diseases under this system.

Perhaps all the evils that civilization brings upon man could be summed up in one pregnant word, *innervation*. The absence of vitality and vigor is a principal source of the lack of all that physical tone and energy so necessary to the discharging of the duties of life. In this the savage is the better man of the two. His active out-door life, his muscular exertion, ensure good digestion and full respiration, pure air, and wholesome food: much muscular waste guarantees the good use of that air and the active assimilation of that food. His nutrition is good and vigorous because his life demands it. Every organ is in constant and healthful activity because its services are required. But it is not so with civilized man. His life of indolence and his sedentary habits cause a sluggish action in all his organs. His physiology is mainly a tradition; his organs act from the impulse inherited from his savage ancestors. Everything about him—digestion, respiration, assimilation, nutrition, secretion, and excretion—has need of the stimulus of muscular exertion. If he exerts himself at all, it is only in one direction, and he employs and develops but one set of muscles at the expense of the rest. He does not require nutrition, and he eats more than he can digest, to his detriment, for superfluous and effete matters are not removed from lack of activity and exercise to stimulate excretion, but they remain to poison the already weakened system.

We conclude, then, that the main influences of civilization upon the development of the teeth, are due (1) to physical depravity following upon luxurious habits, effeminacy, vices, etc.; (2) to the effects, direct and inherited, of disease from the employment of soft and prepared foods; (3) to the preservation of the unfit and their propagation; and (4) to the innervation of physiological processes due to the indolence of civilized life.

(4) Food.

Closely related to the preceding subject is that of the influence of *food* upon the development of the teeth. Most of the writers upon the injurious effects of civilization have laid all the blame at the door of the quality and the ingredients of food, arguing that, as the savage has such good teeth and lives upon natural, raw, unprepared food, his good teeth must be due to that fact, while civilized man, having such defective teeth and employing highly prepared food, with the phosphates all eliminated, etc., his poor teeth must be due to that cause. They have all held that the principal fault was in bolting flour and separating the bran, with the phosphates, from the fine white flour. Now, that flour is not bolted at all, the husk being separated by a process which leaves the outer layer with the kernel, the teeth should begin immediately to improve; but they do not and will not. But this theory had a great popularity in its day, and its day, indeed, is not yet past. Special dieting on unbolted flour, oatmeal, wheaten grits, and other phosphatic food was everywhere prescribed, and with good effect, because the food was good and wholesome, but that it had any direct influence upon the quality of forming teeth we are not prepared to admit.

The whole question turns upon the value of special dieting for a special purpose, and there is much to be said both for and against it.

Buckle said that the history of the civilized nations may be explained by the chemical constitution of the food they eat. Another has said, "Show me the food of a people, and I will tell you what they are." Another, that a handful of English govern two hundred millions of Hindoos because they are beef-eaters and the conquered Hindoos live on rice. We know the Zulu king, when training his warriors for war, feeds them upon meat for a month to make courageous and enduring those who ordinarily live on milk and vegetables; and there is method in the treatment. But the food of the nations which we in our day know is dictated solely by climate and the varieties of food which their environments furnish. The inhabitant of the tropics subsists on fruit and vegetables because the climate requires such a diet and nature provides it abundantly; the Eskimo, within the Arctic Circle, consumes flesh and animal fat because the rigors of the climate demand such a diet to maintain sufficient heat. The inhabitants of the intermediate regions eat both flesh and vegetables, mixed in variable proportions, according to their convenience and the degrees of latitude, altitude, and local climatic conditions and habits of life. Among the civilized nations of the temperate regions there is great variety of diet, the selection of ingredients being controlled by the natural productions of the countries, the occupations and pecuniary circumstances of the people, and by individual preferences. But the ingredients are so various, and so apparently opposite in the different combinations of wholesome diet among different peoples, that we cannot say that any one article or any single collection of articles of diet is necessary to health. The idiosyncrasies of peoples and of individuals have also much to do with the selection of food. In fact, it may be allowed that any combination of articles possessing sufficient variety contains all the necessary chemical ingredients

for the preservation of health and the growth of the individual, provided it is compatible with his habits and idiosyncrasies.

But for medico-physiological purposes special dieting is sometimes resorted to for the production of particular effects. In many diseases the patient is confined to certain articles of food and forbidden others, with marked benefit, and this aside from the question of digestion. The consumptive is fed on cod-liver oil, beef, and stimulants; the diabetic is denied sweet and starchy foods; the plethoric man is forbidden the use of blood-forming foods; and so on, many diseases being successfully treated only with the assistance of special dieting. Then, again, to either increase or reduce flesh special articles of diet are chosen, sometimes with effect. The athlete, the singer, and the race-horse are dieted to improve muscle and respiration. So in many ways special dieting is resorted to for the purpose of producing different effects, food being treated in this use of it as if it were medicinal and would stimulate particular organs or parts to extra exertion.

All this has led to the idea of special dieting for the improvement of the quality of the teeth while developing. It is held that dental defectiveness is largely due to deficiency of the salts of lime, especially the phosphates, and that this deficiency is owing to their being absent from the food eaten. If this were true, of course the thing to do would be to supply the phosphates by eating food which contained them. For this purpose brown bread, oatmeal, whole wheat, etc. have been much prescribed, and eaten by pregnant woman and infants, with a view to improve the quality of the teeth.

In the study of this subject we notice that the teeth are formed during intra-uterine and infantile life, and that the nutrition of the infant during the first part of its existence, both in the intra- and extra-uterine life, is derived from the maternal circulation. During all the period of the formation of the first denture and part of that of the second the constructive materials are drawn from this source, first through the placenta, and then through the mammary glands. Nursing, of course, after the first few months is gradually supplemented and finally displaced by ordinary food. The second denture is thus developed during the mammary and independent food periods. It is necessary, therefore, first, that the maternal circulation should be rich and pure—that it should contain all the organic and inorganic elements of structure as the primary materials from which such tissues as those of which the teeth are composed can be elaborated. As the teeth are largely inorganic, the phosphate and carbonate of lime, etc. being deposited to form dense structures, it follows that any deficiency of these elements will make the teeth weak and non-resisting; and as many teeth are in fact in this condition, it is evident that deficiency of lime salts is the cause. Now, the maternal circulation must be lacking in these important elements, and, being so, the deficiency must be traced farther back—viz. to the food of the mother.

So reason the dieters, and perhaps they are correct. They say that the lime salts must be supplied in the food eaten, or it cannot be furnished to the fœtus. That is undoubtedly true. We know, besides, that the maternal system is drained of its phosphates during pregnancy;

that the bones of the mother are easily fractured and hard to repair during this period; that the teeth are soft and decay readily; all of which goes to show that the phosphates are in excessive demand to form the growing child, and that the maternal circulation must supply them, even if it has to be done by robbing the mother's own structures. Even with that it appears that the teeth of the child do not receive sufficient to ensure a good structure. The deficiency must be supplied by special dieting, by the ingestion of food containing phosphates.

But can we be confident that such food will remedy the evil? Cases have been reported in which special foods have been used with great benefit, but these cases are few compared with the extent to which this diet has been employed. There are few families within the control of the dentists of this country which have not been put upon this diet, and as two or three generations of children have come upon the scene under this regimen, the test should be satisfactory. And what is the result? The teeth of each generation are worse than those of the preceding, and there are but few individual cases where the benefits are at all apparent. In these cases other causes of improvement cannot be eliminated, so that we cannot by reasoning from exclusion, the only proof of experimental fact, assume that the phosphatic diet was the cause of improvement. There is, in the first place, the improved health following upon any special hygienic practice carefully followed, and in that is the secret of special dieting: it is the thoughtful care of the diet and teeth whereby the general health is improved and better teeth are in consequence developed. Then, again, the maternal teeth may be better and the mother's vitality higher at this particular pregnancy than during the former ones, which often occurs; or the environments may be more favorable—less labor and fatigue, less anxiety and emotion, better air and more sunshine, etc. Of course, wholesome food is necessary to perfect development, and plenty of it is one of the elements of perfect health. Good food, well digested and well assimilated, ensures a vigorous physical strength and active functions, and these ensure good teeth; but that a particular form of food is necessary that all people may have perfect dentures cannot be maintained. We know that savage people in different latitudes use different kinds of foods, and that what they use depends on what the environments supply and what the climate requires. A vigorous African will have a good denture though he eats only fruits and nuts; a vigorous Eskimo will have good teeth on a fat and raw-hide diet; and so on throughout the world: the quality of the teeth depends upon the physical vigor of a people more than upon their food.

In the diet of infants after nursing milk is the best food, because it is most readily digested by the infantile stomach and is most natural. It contains the elements of nutrition in a more readily assimilable form than any prepared food or than other food better suited to the older stomach. When it becomes necessary to feed the child from birth, the chances of healthful growth are very much lessened, for no substitute can be found for the mother's milk. Cow's milk is the best substitute, but even this cannot be perfectly digested, owing to its being of an organization different from the human milk to which the infantile organs are adapted. Very little nutrition is obtained from it, and the child suffers from slow

starvation, to which it not infrequently succumbs. Condensed milk, patent baby foods, prepared extracts from adult foods, are all of them unnatural and unwholesome. Infants reared on these foods have been noticed in which the teeth were poor in structure and sometimes pitted. Cow's milk is much better than these, as it is more easily digested and the developing teeth are better supplied with the elements of structure. But for the mother of the fœtus and for the nursing child we hold that the foods of any people, savage or civilized, provided they are adapted to the idiosyncrasies of the individual, if wholesome in quality and sufficient in quantity, are adequate to produce good teeth. But if the food is unwholesome or insufficient, the teeth, with every other part of the system, will suffer. The phosphates are not necessarily excluded from any wholesome and palatable diet. Investigations have demonstrated that it is more a matter of assimilation than of the quality of the food consumed. If the food is natural to the person, it is digested and assimilated and converted into tissue; if it is unwholesome, it is neither digested nor assimilated.

Again, the phosphates—of lime especially—enter into the structures of all tissues. Their administration as a medicine serves the purposes of an active tonic, constructive and stimulant to the nerves and tissues. In pregnancy, nursing, and infancy they are necessary for constructive purposes, and nature supplies them in any well-assorted dietary. If excess is prescribed to build stronger teeth, what assurance have we that that excess will go to make dental tissue? It may go to make nervous substance, or bone, or muscle. So its special administration is practically useless. The point to be insisted on is that the food of the mother, of the hand-raised infaut, and of childhood must be natural, wholesome, and abundant.

We conclude, then, (1) that defective teeth are not due to the elimination of the phosphates by the bolting of flour, and (2) that special dieting to supply the lime salts cannot benefit them; but (3) that food has an influence upon the development of the teeth only as it affects the growth and health of other tissues. If it is natural, wholesome, and abundant, and is well digested and assimilated, the teeth will be strong and vigorous, or *vice versâ;* and (4) that any ordinary dietary contains all the elements necessary for nutrition and development.

(5) Nervous Disturbances.

This subject is also closely connected with that of civilization; indeed, is a sequence of civilization, a product. Through the influence of that higher life of intellectual activity, of investigation, research, reasoning, and controversy, civilized man has pushed the development and activity of his nervous system to a dangerous extreme, and is even now paying the penalty of his elevation by the rapid multiplication of nervous diseases. Nervous excess is, indeed, the curse of modern civilization. It puts the feelings and emotions upon a high tension, and the jars of life play a painful discord upon the strings. Civilized man is hypersensitive. He thinks too much, he feels too much, he enjoys and he suffers too much. Intellectual pleasures have too much superseded

physical enjoyment. Nervous development is in excess of the physical, because he cultivates the former at the expense of the latter. He has a strong mind in a weak body. But the circumstances of civilized life drive him to a mental activity and intellectual effort beyond his strength of body to endure and at the same time retain health. The struggle for existence is, with him, transferred from the physical to the mental fields of controversy, but it is none the less fierce and merciless. A competition of mind exists which drives him to continual exertion, with the effect of constant stimulus of the nervous powers. This stimulus leads to hyperdevelopment, hyperactivity, and hypersensitiveness. In addition to the work of the brain is the wear of "worry" and anxiety connected with all the affairs of our modern life; and the "worry" wears out more than the work. As if the mental strain of brain-labor were not sufficient, this demon of "worry" must come in to assist in driving modern mankind to the madhouse. And "fathers, under a mental strain which drives them to the verge of insanity, transmit that exaltation to their offspring, and thus we see a generation of children inheriting a tendency to nervous exaltation which makes them no longer children, except in their immature physical development. . . . The primary cause, so far as the individual is concerned, of any general disturbance of the development, especially as regards malposition, is traceable to lesion or innervation of the trigeminal nerve, disturbing its functions, one of which is presiding over the development of the teeth" (Kingsley).

Concomitant with the intellectual excess, as a resultant of hyperdevelopment of the nervous system and the demands of civilized life, is the greater evil of *emotional excess.* With the tension of modern life, the excitement, the pursuit of pleasure, and the social and business strains, it is small wonder that we have acquired and transmitted an excess of feeling and emotion. Our emotions are wrought up to a pitch that the savage never experiences, and hysteria is almost a chronic condition of the highest developed and most intellectual classes.

Dr. C. F. Taylor in a paper upon "Emotional Prodigality" gives an excellent elaboration of this subject and the pernicious effect of cultivating the emotions in children. He says: "It is unquestionably true that an active, well-trained *thinking* capacity imparts positive strength to the bodily powers. It is not the *thinking* that breaks the body down, but it is the unnecessary excess of other mental activities, in which I would include the *emotions*—the most exhausting of all mental attributes. It is the emotion which so often accompanies thought which tires and exhausts the body more than the thinking. The emotional, excitable man can do less intellectual work than the calm and placid man, for his emotions exhaust him more than the work. Women are more emotional in civilized than in savage life, and the so-called 'higher education' seems to increase this emotionality and excitability." The transmission of this excitability is an increasing evil. "Inheriting nervousness, the child is born into a hotbed of emotion, and its education is æsthetic and emotional; society then excites and social pleasures exhaust the girl, till the modern woman becomes the bundle of nerves that she is, and totally unfit to become the mother of children in turn,

and which are born with big heads and little bodies, and almost no digestion at all. The emotional life into which such children are ushered is a hundred times more hurtful than the most intense intellectual strain which can be put upon the child. And this, under the injurious competitive and ambitious system in vogue in our schools, is bad enough. . . . . There is a law of human force which proclaims that for every atom used in one direction there is an equivalent atom wanting in some other direction. How can there be a well-developed body in a child whose brain is kept excited by emotions, and in whom a waste of force is going on far beyond the means of supply except by drawing from other directions? Thus the brain is supplied in part at the expense of the body, and the worst of it is there are no proper compensations. On the contrary, a condition of preternatural emotional preponderance is established as an inveterate habit of life; hence the great number of nervous invalids.

"Such are the products of that civilization which we boast of, but which does not apply its knowledge to prevent these things; for the causes are largely preventable. Greater caution should be used against over-action of the brains of children, especially in the direction of the emotions, which have too often a malicious effect upon bodily development, such as feebleness, asymmetry, excitability, premature arrest of growth, etc. The population of cities is dwarfed and destroyed by the excitability of city life, which forces the brain and suppresses the body. . . . . There are very few well-formed bodies among our young women. They impress us as having been *starved*, and starved they literally are. The body has been starved to keep up the drain upon the brain. The overwrought brains of our 'civilized' children absorb an undue amount of the vital forces, and thus the body is left to starve. Hence ill shapes and distortions, or want of symmetry in the trunk, or disproportion in the extremities. Hence weak muscles and indigestion. Hence teeth imperfect in development, dentine soft, enamel defective and easily penetrated. Hence decay."

Nothing can be added to this exposition of the effect of the nervous strain of emotion, the most debilitating of all nervous action upon the development of the teeth. Nervous excess in this direction implies hypernutrition of the brain; this hypernutrition means deficient nutrition of the growing body of childhood, which in its turn means deficient formation of the teeth. Cause and effect were never more closely related and the relation more demonstrable. In the study of this subject we must remember the close anatomical relationship which exists between the teeth and the nervous system. The sympathy and responsive sensitiveness existing between them are intense and wonderful, and would be incomprehensible did we not consider that relationship. This is embryological in its history, for the dental and the nervous tissues both originate from the derm, and largely from epithelium, the product of the epiblast. How far both may be transformed epithelium we cannot yet say, but when we contemplate the wonderful transformation of epithelium into stellate cells in the enamel-organ and into ameloblasts, we can believe that a similar metamorphosis could originate nervous substance. All sensory organs are evolved from the epiblastic layer

and from epithelium, and the brain and its appendages are but highly elaborated sensory organs.

The teeth are in a moderate degree sensory organs; they partake of direct and sympathetic sensation, and pain in and from them is of that variety which is peculiarly keen and incisive, as of nervous substance in disturbance. But in the matter of effecting perversion of nutrition of the teeth during development nervous excess and excitability or hyperæsthesia is a prime factor, on account of its close embryological relationship. The sympathy is so acute that disturbances of the nerve-centres are more liable to be reflected in the developing teeth than in any other parts. Deprivation of nutrition on account of the excessive demands of the active or excited brain would touch the teeth first as related organs and the first to be reached. Themselves demanding an excess of nutrition, an ebb in the flow of pabulum would be first noted in them by deficient formation at that time, while many other organs would not record the deficiency. The intimate anatomic relationship of the teeth and the nervous system is thus sufficient to account for the effect of nervous disturbances.

This subject has been discussed by Dr. N. W. Kingsley, who believes that nervous excess is the cause of much of the irregularity and other dental lesions prevalent in modern high life. He says: "Decaying teeth and nervous diseases are correlated: each is symptomatic of a common cause—*neurasthenia*, nervous exhaustion, an absence of a reserve nerve-force. . . . . Parents whose teeth are decaying because of diverted nutrition and exhausted nervous force transmit, by the immutable laws of inheritance, this condition to their posterity, and it becomes in them constitutional. Entering life under such predisposing circumstances, the child must inevitably show a faulty physique with poorly-organized teeth. Every mental or emotional excitement in early childhood or stimulus to mental exertion only aggravates the tendency, and the teeth readily succumb to destructive agencies which would otherwise be harmless. The physiological law and its rationale are very similar. Excessive mental or emotional activity impairs digestion, and it diverts nutrition to the brain to repair undue waste: from lack of nutrition the teeth become degraded, and fall an easy prey to the aggressive agencies generated by the same disordered and defective assimilation. Given an unimpaired nervous system in a sound body without inherited taint, and teeth would never decay so long as that condition was maintained.

In regard to the effects of actual mental disease upon the development of the teeth a large field lies before us which has been but partially explored. Disease of the nervous substance during the formation of the teeth cannot but affect them deleteriously. The most rapid growth of the brain takes place before seven years of age, and it must be remembered that the crowns of the permanent teeth, except the third molars, are formed before that age and simultaneously with the growth of the brain. Any derangement of the nervous evolution, either of excess or diminution of quantity or quality, even the drain of its normal growth (and especially of abnormal growth), is sure to produce a reflected impression upon the teeth. "The nervous centre in which the trigem-

inus is implanted is the one which in the human subject is most liable to congenital imperfection of the kind which necessitates a breakdown in its governing functions at special crises in the development of the organism" (Anstie). Any abnormality—and even the excessive tax put upon children, either intellectual or emotional, is an abnormality—affects the development of teeth or their supporting maxilla by its reduction, thus causing crowding and irregularity. "During the formative and eruptive periods of the permanent teeth they are under the influence of an independent and peculiar vital (nervous) force; this innervation pushes on their development regardless of the tardy growth of the osseous system, and, being implanted in a crowded position, they never have an opportunity to recover from it, but emerge in the same disorder. The correlation and the connection would seem to be unmistakable. A disturbance of function would produce general results the details of which might vary in every case."

In following out these deductions Dr. Kingsley came to the conclusion that his theories would be verified or disproved by an examination of the mouths of microcephales or macrocephales, or persons with weak and sluggish intellects. He argued that "if a precocious or stimulated brain in infancy urges on and crowds the dental organs in advance of the growth of the jaws, then a brain of low calibre or power will be likely to have associated with it a retarded dentition, but with abundance of room," and that "in idiots we shall be likely to find capacious jaws and teeth not crowded." Dr. Langdon Down's investigations of one thousand feeble-minded children did not at first confirm Dr. Kingsley's conclusions. Dr. Down's most startling statement was that "a marked character of the teeth of idiots is their irregularity as to position, being often very crowded, the jaws narrow, the palate vaulted." Dr. Kingsley had found the contracted vault associated with a higher order of intelligence, so he undertook observations himself. In visiting the first institution he examined two hundred idiots. He found no V-shaped arch, but few narrowed palates, little irregularity, many cases of retarded dentition, and no unusual amount of other dental diseases, but asymmetrical formation of the jaws. In another place he examined three hundred and fifty idiots, and in Paris visited similar institutions and made diagrams of thousands of mouths of children in public schools and of people of various nationalities, and found no more irregularity than in the lower classes everywhere. In the idiots of France and the cretins of Switzerland he did not find a single case of narrowed arch or vaulted palate. "In the lowest stages of hopeless idiocy the jaws and teeth, and indeed the whole physical condition, were degenerate, beginning with a sluggish or feeble mind in a fair organization with well-developed jaws, descending in regular sequence through all the grades of imbecility to unconditional vacuity, associated with corresponding disorganization and degeneracy of the teeth, jaws, and the whole physical system. With Dr. Down he visited that gentleman's institution near London and made a careful survey of the inmates. They found a "larger percentage of irregularities than usual, but only about 5 per cent. of pronounced cases of V-shaped arches and 10 per cent. with slight contraction, but none so marked as those he had

treated in private practice and associated with the highest intellectual development. But there was a larger percentage of irregularities in this collection of idiots than in any other which Dr. Kingsley had examined, nearly all of whom were from the noble families and consequently originating in an educated race. He says: "Let it be borne in mind that no irregularity in the position of the teeth is any evidence of idiocy. It is so often associated with high intelligence that if any inference were to be drawn it would be that it was more likely to indicate precocity in the individual. An inherited taint, disturbance, lesion, predisposition, or tendency to idiocy, of which these irregularities are only the symptoms, may show itself in a precocious mental development in one instance, and be the precursor of insanity in the same individual or appear as idiocy in posterity. In private practice I have seen dental deformity associated usually with intellectual capacity above the average. In the public schools it is associated with mental brightness when from the middle and lower classes. In children of good physique and fair mental capacity the development was on the whole regular and normal. In congenital idiocy there is only a small percentage of pronounced irregularity, and that generally associated with the lowest type of idiocy. With these deformities were usually other abnormalities of physique, showing a general constitutional disturbance.

"A perfect dental development is the result of well-balanced physical and nervous systems without hereditary taint. Abnormalities of development are due to a disturbance of the trigeminal nerve during the period of the formation of the crown of the permanent teeth. It may be an inherited tendency to a like disturbance in a progenitor or the result of mixing of ill-assorted types. A feeble mind, a sluggish brain, or a dull intellect is a nerve lesion or brain disturbance, and when associated with an average physique the dentition is tardy but regular. Neither lunacy nor insanity can have any direct bearing upon the development of the teeth, but such a condition would be most potent for evil if transmitted.

"I do not hesitate to place it upon record that the next generation will see more of abnormality in dental development and an increase of nervous and cerebral diseases, and that the two are correlated and spring from the same cause."

Dr. Kingsley thus believes that dental defectiveness and irregularities are not necessarily symptomatic of nervous lesions, but that the two are correlated and often associated. As irregularity is often accompanied by intellectual precocity, it may be said to be a sign of nervous excess in such persons. Dr. Garretson was of opinion that a deep arch indicated lack of mental force. Dr. J. W. White, who made extensive observations in this line, was of the opposite opinion and agreed with Dr. Kingsley. He examined the mouths of the inmates of several institutions and gave the subject much study.

We may conclude (1) that nervous excess, emotionality, intellectual strain, etc. are causes of perverted nutrition, and so affect the development of teeth; (2) that precocity and emotion in children as encouraged by modern life are destructive of wholesome nutrition of the teeth; and

(3) that diseased nervous organizations affect nutrition in the same way and cause perversion of dental development in various degrees.

(6) Diseases.

Under this head we have to consider those disturbances of function in relation to the development of the teeth which are strictly pathological, and which eventuate in defects and deformities of the teeth which are more or less pathognomonic. That diseases do pervert nutrition or injure formative organs, and so disturb the formation of the teeth, we are only too well aware; but as to *how* the various disturbances of development are effected we are yet uninformed. Perversion of nutrition, either by the pabulum being filled with the poison of the disease or with the diseased products, or through its insufficiency, is a first potent cause, the effect of the disease-poison upon the formative organ causing the death or rupture of ameloblasts or odontoblasts singly or in areas, and giving rise to defective places in the enamel or dentine, or inducing the innervation of parts of the organ or of the whole of it, thereby producing stunted or asymmetrical products, or resulting in the total destruction of the organ. By still other methods unknown to us disease may affect the developing tooth and cause it to be deformed or imperfect. Several authors and observers have given reasons for their belief that some forms of defective enamel are not caused by disease during formation, but by the defect of acrid fluids during the process of eruption. From this opinion we must dissent. The evidence is yet upon the side of the congenital and follicular effects of disease. Some forms of defects they concede are prenatal in origin. We hold that all formed teeth are unaltered after formation, either in the follicle or after eruption, and that defects of growth are due to perverted nutrition during growth. As Magitot says: "If the alteration were chemical in its nature, there would be no alteration in the centre of the organ, which is always present. Congenital lesion of the teeth, fissures, erosion, etc. are exclusively due to disturbances of the dentinification and belong to the history of the follicular evolution."

Without attempting elaboration of the methods or phenomena of the pathological influences, we will hasten on to a presentation of the theories of different observers upon the effect of various diseases. Without approving or condemning their conclusions, we will endeavor to present as comprehensive a view as possible of the dental phenomena pathognomonic of different diseases as described by various writers.

With this end in view we will, for convenience, classify the diseases affecting the development of the teeth, as follows:

(1) Congenital or Hereditary;

(2) Infantile or Acquired.

(1) Congenital or Hereditary.—Diseases causing physiological perversion induce constitutional conditions which are generally described as *diatheses* or *cachexiæ*, with the distinction that "diathesis" means rather a physiological disposition barely abnormal, while "cachexia" means a condition necessarily pathological. Persons inheriting a constitutional disease are vitiated with that cachexia as a consti-

tutional vice and predisposition to disease. The entire system is saturated with and impressed by a foreign substance and influence which disturbs the normal action of organs and thus impairs the general health. The fœtus which inherits such an influence from its parents is under the control of a vicious power which combats physiological action and prevents perfection of evolution. The development of organs is retarded or misdirected, and the result is defectiveness and imperfection. The developing teeth, being so sensitive to disturbing influences, are readily affected by these constitutional diseases, and the peculiar cachexia prevailing impresses the growing tooth with more or less permanent characters which are pathognomonic of the disease. These characters are but indifferently understood, and where assigned arbitrarily to any one disease or influence must be accepted with caution. Except in the case of syphilis we are by no means certain of the symptomatic value of any cognizable markings upon the teeth. These markings are very varied, and will be given when described by the observers quoted in regard to each disease. The conclusions of these observers must, however, be accepted as tentative, for we have little reliable evidence upon the subject of the diagnostic value of any of the pathognomonic features of affected teeth. We will endeavor to be as comprehensive as possible in our review, without attempting to defend or refute the opinions of various writers, our object being to present evidence on all diseases without passing judgment as to the conclusions to be drawn. We act in the capacity of a collector of evidence, and leave to others the analysis and philosophy, merely desiring to give an epitome of our present knowledge of the subject.

Syphilis (*Cachexia Syphilitica*).—This "prince of diseases" holds first place as a disturber of nutrition and assimilation in the dental formative organs, and is a prime cause of defective organization, both in form and structure, of the dental tissues. The destructive and lasting impressions it produces upon the teeth in embryo are unparalleled in pathological history. They are an ineradicable, hopeless deformity. Its effects range from slight imperfection of quality or form down, through various degrees of incompleteness, to a stage of riddling and atrophy that is pitiful to contemplate, and beyond this is the condition of total destruction of the organ and the tooth. Its usual manifestations are in aberrations of form and quality of tooth, which are at once apparent and diagnostic to the trained eye. The especial effect of the malassimilation which syphilis induces is to reduce the growing germ and give birth to a stunted tooth possessed of peculiar markings which are diagnostic of the disease. "The sins of the fathers are visited upon the children" with a vengeance which is as precise as it is merciless. The markings are now held to be pathognomonic and invariable, within certain limits, by syphilographers. The labors of Hutchinson and others have done much to elucidate the obscure subject, but of course much yet remains to be done. Many markings cannot be distinguished from those of other cachexiæ, and a complete differentiation has yet to be attained. The most significant sign is the "Hutchinson notch" (Fig. 81), which is like a crescent-shaped depression upon the edge of the incisors. The tooth-crown is much shrunken in form, and the edge has the appear-

ance of being broken in a semicircle, and on this edge is the semilunar notch. This is a reliable pathognomonic sign. Mr. Hutchinson says: "The malformation which was diagnostic of the disease was a special and very peculiar one. It consisted of dwarfing and notching of the upper centrals of the permanent set." If this condition of this pair of teeth were not present all other deformities should count for nothing.

FIG. 81.

He thought this a reliable symptom, and all recent observations had tended to confirm it. But it varied in degree and required some practice to appreciate it. In many cases of hereditary syphilis the teeth were but little malformed. He believes that the malformation was due to inflammation of the dental structures at an early period of infantile life. He had had many opportunities for seeing families of syphilitic children, and had always found the malformation of teeth most marked in the eldest and becoming gradually less so in the younger members. He added the observation that these peculiarities are never met with in the first set of teeth. He did not believe, besides, that syphilis had anything whatever to do with one-tenth of the cases of malformation of the teeth which came under notice.

Mr. Stanley described cases of "interstitial keratitis with characteristic syphilitic teeth. The upper incisors were typical, narrow, with corners rounded off; in the centre of the cutting edge was a deep vertical notch which was prolonged upward by a shallow groove in the middle of the front surface of the tooth; lower centrals narrow, peg-like, and notched; laterals normal. In another case of double interstitial keratitis with a syphilitic history the upper centrals presented a broad notch at their cutting edges; teeth not so narrowed as in the previous case, but there was present atrophy of the middle lobe of the tooth; lower centrals serrrated, but not notched."

Dr. Fitch says: "If syphilis is present in the infantile system, its virulence is especially exhibited upon the dental apparatus. It causes small dark grooves or pits which lead to caries. Exfoliation of the teeth often occurs as a secondary effect of syphilis in later life."

A case of a girl of eleven years is reported who had double keratitis, malformed teeth, and syphilitic cachexia. The double keratitis had occurred at an early age, a lachrymal sac had abscessed, the deciduous teeth had fallen out at three years, and for three years afterward she was wholly edentulous. Epilepsy is often an accompaniment of syphilis. Cases are reported with a syphilitic history and characteristic teeth.

M. Magitot does not think that the notch is characteristic, and states "that it is not found in some races frequently affected by syphilis, such as the Japanese and Peruvians. Not only inherited syphilis, but also all other serious troubles of nutrition, may cause diminution in the number and size of the teeth or delay in their eruption, but never

erosion." Again, he says:[1] "A syphilitic diathesis produces especially disastrous effects upon the teeth, and we see in infants affected with hereditary syphilis small, deformed teeth with deep fissures, whose enamel and ivory, imperfectly calcified, are permeated with opaque spots and remain weak and brittle."

Albrecht criticises Hutchinson's conclusions as to the diagnostic value of syphilitic markings on the teeth, and says that "the proofs are still wanting of the occurrence of an hereditary syphilitic deformity of the teeth."

Dr. Langdon Down found that among feeble-minded children "very few had syphilitic teeth, but when present they always accompanied a syphilitic history, and were invariably associated with the chronic keratitis spoken of by Mr. Hutchinson."

Dr. H. W. Williams says: "The central incisors of the second dentition have a peculiar crescentic notch at their lower margins, and the lateral incisors and canines, as well as the molars, are often small, peg-shaped, and with tuberculated prominences upon their surface. They are also, perhaps, irregularly set in the jaws, of bad color, and often decay early."

Dr. T. B. Hitchcock says that "these conditions have been recognized for some years as diagnostic of syphilis, but they must not be confounded with those markings which occur as the result of interrupted development, such as the longitudinal grooving, with depressions or pits in the enamel, caused by a perversion of nutrition induced by some of the non-specific infantile diseases. Mr. Hutchinson and Dr. Williams give cases where the deciduous teeth are affected, but such cases are not often seen, because the subjects of interstitial keratitis do not, as a rule, come under the observation of the oculist until after the temporary teeth are lost."

The writer observed the case of a boy of seven in whom all the teeth, deciduous and permanent, were affected so far as they were present, but the markings—none like erosion—may not have been entirely due to syphilis.

Dr. Laycock says that in the syphilitic diathesis "the head is rarely well formed, the forehead being protuberant, the stature stunted, the belly large, the joints often diseased, the nose shrunken and flattened, with opacities of the cornea from early corneitis, scars of old fissures about the angle of the mouth, enlarged and hard cervical glands, complexion of a pale, earthy tint, the skin sometimes thin and stretched, or, again, dingy, coarse, and flabby, etc. The nails are often stumpy, brittle, and ragged; the teeth as Mr. Hutchinson has described, but the notch soon wears out, so that at the age of twenty to thirty they are like ordinary teeth at sixty."

Mr. Paget said that "this malformation of the teeth is not to be found in all cases of congenital syphilis, but when present it is a reliable diagnostic sign. The teeth are distinct, having wide interspaces: they are disproportionately small, narrow, and lessened toward the edge, which presents the crescent or half-moon notch on the cutting edge; the edge of the notch is not broken, but rounded off singularly. This notch

[1] *Dental Caries.*

is rarely seen after thirty, as the edge becomes worn straight off. As to the cause of the peculiarity of the teeth, there are certain correlations of disease parallel with the correlations of growth which Mr. Darwin has illustrated, and, like them, quite inexplicable. All that seems certain is that with certain morbid conditions of the blood there is a complemental nutrition which induces changes in organs and tissues."

Mr. George Barraclough, in defending the "Contagious Diseases Act," says: "I attach much importance to affections of the teeth in enabling us to diagnose hereditary taint, because of all syphilitic lesions they are most constant. That this constancy should exist and the affection be so well marked need not excite surprise when we consider that the teeth stand, as it were, structurally, halfway between the endo- and exo-skeletons. . . . . There are often gaping spaces between the incisors. Cases are noted where serration is angular, cut down on lower centrals; upper incisors incline to be circular. A boy of eight and a half years had incisors discolored below the black line across the front face; above that the enamel was good and white. The black line across the face is sometimes the only sign of taint. A woman had incisors of enormous magnitude and which possessed the angular lateral slope. Excessively large teeth resembling tusks of lower animals are not unusual accompaniments of taint; simple and solitary ulcers sometimes occur on the enamel, having a dark base. It is this ulcer which produces the semicircular notch, perhaps, at the edge. . . . . Sometimes there is a vertical line accompanied with white spots. Again, the edges of the incisors will present the appearance of having been sawn in sections and then cemented together, the joints being distinct, or there will be a transverse fluted appearance."

One of the most excellent elaborations of the subject of syphilitic teeth is an essay by Alfred Fournier, translated by J. Wm. White, M. D., and published in the *Dental Cosmos* (vol. xxvi. pp. 12, 81, 141). After referring to the diagnostic value of syphilitic markings, he says: "It shows itself in two ways, very unequal in diagnostic value: 1st, by retardation of evolution; and 2d, by the arrest of growth and modification of structure. Retardation was noticed in the last century by Sanchez, and by many authors since. I have notes of cases of teeth not appearing until before ten, twelve, or fifteen months. Sometimes the retardation is limited to one group, however, the incisors for example. Sometimes a similar retardation occurs in the times of the eruption of the permanent teeth. This retardation of dental evolution is but a local expression of a general retardation of development, the growth occurring in a slow and imperfect manner. . . . .

"In regard to the second manifestation, we notice, first, *dental erosion*, as resulting from hereditary syphilis. The tooth appears worn, corroded, or honeycombed on portions of its surface. Erosion properly means wear or destruction after formation, but the tooth was of the form in which it is seen years after before it emerged from the gum, and the malformation is due to imperfect and incomplete formation. There is, first, the *erosion en cupule*, like little cups, from a pinpoint in size to a pinhead or larger. At first they are white or yellow, and darken with age. They affect the incisors first and most, and the cen-

trals most frequently of these. *Erosion en facettes* is not so common. It affects especially the incisors, and looks as if made by a file on various planes, producing facets. This lesion is not easily noticed, and frequently escapes observation. It sometimes looks as if fragments had scaled from the tooth. *Erosion en sillon* is the variety denominated by M. Parrot as the furrow-like or sulciform dental atrophy, and is the most common form, consisting of linear transverse grooves. Sometimes it goes entirely around the tooth like a ring, or, again, it is interrupted. It may even consist of a finely-punctated line. One form is lineal and superficial, like a pen-mark on paper or the cut of a knife in wood. The other form is a deep gutter, a true furrow. Both are rigorously horizontal. Commonly there is but one furrow, but, again, there will be two or three, all below the middle line. These used to be called 'stair-' or 'step-like' teeth. The edge is usually thin, brown, and rough, and is soon worn off. *Erosion en nappe* is that in which there is greater surface erosion—an exaggeration of the preceding types, often covering the entire crown and obliterating its natural shape and structure.

"Another group of surface erosions affect the free edge of the tooth, and present their malformations under different forms as they affect different classes of teeth. The first molars, for instance, may have their first two-thirds well formed and the cusps be atrophied beyond recognition, or they may present other and various malformations. They afterward often wear smoothly down. On the cuspids a simple notch of the cusp may be present or the point may be atrophied. The bicuspids may also be affected similarly. The incisors may present the angular notch of the free edge or an atrophic thinning of it, or it may be rough and pitted.

"Then, lastly, there is the Hutchinson notch, which is well known.

"To these may be added other defects and deformities more or less associated with syphilis, and many of them also with other lesions and disturbances of nutrition." Indeed, so frequently are all forms of syphilitic markings, except the Hutchinson notch, simulated by other disturbances that they are valueless as pathognomonic and diagnostic signs, and the notch is the only one which can be said to be invariably and unmistakably indicative of hereditary syphilis and a syphilitic diathesis.

Scrofula (*Cachexia Scrofulosa*).—The effect of hereditary scrofula is frequently marked in its influence upon the developing teeth, but not with a distinctness to be sufficiently distinguishable as a diagnostic sign. It seems to produce an indefinite atrophy, imperfection, and softness of the enamel and dentine, rendering such teeth prone to caries, with a pinkish, muddy, opaque color. A close examination of the internal structure of the teeth of this cachexia would perhaps discover a prevailing form of imperfection as accompanying it. As a racial characteristic it is prevalent in the negro race and its hybrids in the United States, and in the Swedes who emigrate to this country. In both these peoples it induces defective dental structures in greater or less degree as the individual is more or less tainted. As scrofula is closely related to syphilis, if indeed not directly descended from it, its workings cannot perhaps be distinguished from that cachexia with any

certainty, and they have in consequence no direct pathognomonic value. The effects are much like those of exhausted syphilitic taint.

Prof. Chapin A. Harris describes teeth of "Class Third" of his classification as being muddy white in color, large, rough, and irregular, the lingual surfaces indented, the arch broad, the teeth regular, but inclined to project, and he says that these teeth are usually found in persons of strumous diathesis.

Dr. Laycock says: "The teeth in the scrofulous diathesis present the signs of imperfect development and nutrition, but these vary much in individuals. Sometimes they are remarkably large, with milk-white spots on the flat surface, indicating defects in the enamel at which caries usually begins. In this respect the caries of the scrofulous tooth differs from other cachexiæ, in which it begins on the approximate surfaces, fissures, etc. Sometimes the teeth are very irregularly set, the central incisors leaning toward each other and overlapping, as in the rabbit jaw."

Dr. J. W. Ellis says the scrofulous or strumous diathesis is characterized by depositions in various localities tending to extensive degeneration. The influence of struma in deranging the osseous or dental tissues has been considered very remote, and Rotkitansky in his classification places bones and teeth at No. 11 in total 15 of his scale.

However, as Dr. Laycock says, the strumous diathesis is so often modified by syphilitic mixture that the two are scarcely distinguishable in their varieties. Indeed, syphilis itself, when pronounced, is modified by a previous taint prevailing, whether scrofula, gout, rheumatism, phthisis, etc., and these in turn are altered in their physiognomy by the great vice; or the degeneration is modified as to tissues, different ones being affected in different diatheses. Surgeons have frequently noticed the carious condition of the teeth of strumous character associated with hip-joint disease in children. When this strumous condition is crossed with syphilis the complications are difficult to unravel.

Dark-brown spots are sometimes found upon the teeth in this diathesis, and are more or less pathognomonic; but as they occur in other cachexiæ and from infantile diseases, such defects are of no diagnostic value alone, but when found with hereditary scrofula may be said to be derived from that derangement of nutrition and are one of the signs of its prevalence. Taken with other symptoms, they are complementary indications of scrofulosis.

Rachitis.—The rachitic diathesis is often closely related to the syphilitic, and again can be differentiated from it. "It appears to be intimately connected with a marked cachexia of the system which seems to be identical with the scrofulous, and to be induced by insufficient nourishment combined with damp, foul air. Deficiency of the phosphates is the prime cause of the disease, which causes ill-growth of the bones and teeth" (Joseph Jones, M. D.).

Dr. Jenner observes that "among the most constant and striking anatomical lesions in rickets is the arrest of growth, not only of the bones, but of all the parts directly related to the bones—muscles, vessels, nerves, and teeth. It usually retards dentition, so that, other causes being excluded, when dentition is delayed beyond the ninth or tenth

month rickets should be considered. The rickety deformity may be very trifling, yet the teeth be much retarded. The general deficiency of growth also affects the teeth.

"Guerin found that of 346 cases of rickets 208 were affected between the first and third year, 3 congenital, and the others before the twelfth year; 148 were males, 198 females. Cases of congenital rachitis were mentioned by Hippocrates and other ancient writers. It was discovered in a seven-months' fœtus, and occurs in other animals, notably lions and tigers in captivity and in dogs and cats under experiment. Softening of the bones in rachitis is due to arrested development caused by deficiency of lime phosphates. The deficiency is only temporary, and after the resumption of the power of assimilation development goes on with renewed activity, so that persons who have been rickety in infancy and afterward recovered usually develop unusual strength. This is often manifested by dwarfs who are small by reason of infantile rickets."

Dr. Bohn says: "Rachitis retards dentition, because the teeth are, more than any other part of the skeleton, influenced by any disorder of the constitution which injures ossification."

Sir William Jenner has shown that "rickets is the most common cause of retarded dentition. This effect is peculiar to rickets among diseases of nutrition. In cases at three years of age only six teeth had appeared. Sometimes the teeth when erupted become black and decay soon, owing, as Vogel has shown, to insufficient development of the enamel. In the case of a lad of five the teeth dropped out undecayed." Indeed, rickety persons sometimes remain toothless during life (Van Swieten).

Dr. John S. Parry says that owing to the imperfect development of the jaws the teeth are crowded and irregular, and painful in eruption. This is also often the cause of retardation. The teeth themselves are imperfectly developed, deficient in enamel; they decay in a short time, and often appear to merely fall to pieces. A rickety child is often toothless long before the permanent teeth appear.

Dr. Kendall says that "rachitis is characterized by non-solidification of the growing layers of bone, and excess in the formation of phosphorous and lactic acids and also of the earthy phosphates. It is congenital, and affects the condition of the growing teeth by delaying their development, disposing them to caries, making attachments loose, the pulp and peridentium presenting the general amyloid degeneration seen in the viscera; the teeth are imperfect, mottled with uncalcified spots and interglobular spaces. It is often accompanied with scrofulosis or syphilis of an hereditary character."

Dr. Alfred Carpenter says: "Rachitis is a disease of the bones in which the phosphate of lime is very deficient, the bones are soft and cellular, the teeth are defective, the intellect inferior from inertness of cerebral action. Artificial feeding is a principal cause of it when not congenital, and in large cities, amongst the poor, where the milk is of the poorest, it is very prevalent. Artificial foods, which are still more deficient in phosphates, render it worse. The teeth, with the other osseous and nervous tissues, fail of perfection and strength. Again,

rickets can be produced in animals either by deficiency or excess of the phosphates in their food."

Magitot says: "Rachitis disturbs the phases of dental evolution, producing diminution in their volume, an habitual pale and transparent tint, and delicate texture."

Many eminent physicians regard rickets as a descendant of syphilis, an expiring effort of the great vice, and many others equally eminent regard it as not related to syphilis at all, but a fault of nutrition depending on various causes. Dr. Adolph Baginsky says: "Rickets is a dyscrasia originated by an alteration in the general nutrition which may be caused by the various noxious influences working upon the infantile system."

Tubercle, Phthisis (*the Cachexia Tuberculosa*), often produces teeth of especial clearness and transparency and of frail structure. Then, again, consumptives will possess teeth of peculiar beauty and strength, but in these cases the disease is usually acquired and not inherited. But the transmitted tendency to tubercle is that diathesis which tends to the development of centres of degeneration with constitutional weakness of structures.

Dr. Alfred Carpenter says: "Caries is favored by the condition which promotes tubercular tendencies: a minute particle of perverted protoplasm is laid down in the cell-membrane which forms the dentine, and which is chemically defective from having a tendency to fatty degeneration rather than to proper deposit of phosphate salts. One or more cells may be touched, and as time goes on these cells soften, there is want of balance in the dentine and enamel in organic elements, and a defect will soon lead to degeneration and decay. The teeth of children of tuberculous parents should be well cared for. Germs of perverted protoplasm are found in the dental organs as well as in other epithelial structures. The teeth show a want of true bone and true enamel; the material provided is fatty and friable; and with this state of the teeth there is often a tendency to bow-legs and soft, irregular skulls; there is defective innervation, which has arisen from foul air, deficient sunlight, and bad food acting upon the defective constitution. Often, when the evil has fallen upon the epidermis and has shown itself in defective teeth, with scaly or vesicular eruptions upon the skin, the internal organs have escaped, and the subjects, having thus thrown out the morbific matters, have grown up into healthy, well-developed individuals."

Dr. A. C. Castle says: "The teeth of phthisical persons present internal disease in the original imperfect ossification of the dental tissues, which are almost cartilaginous in their texture; they present gelatinous matter, saturated, as it were, with solidified lime from a gristly bone-solution, and covered with a delicate, translucent, imperfectly crystallized enamel. In the centre substance of these teeth may be seen a deep-seated blue spot like a bruise, which exhibits tuberculous tissue. We find the germs of malignant disease in the organization of the teeth as well as in the lungs and the other organs of the body. A case of a consumptive whose disease was rapid is noted, whose teeth were perfect and of surpassing beauty, but which crumbled with caries before

death. These blue-white, pearly teeth are but one remove from the gelatinous organization of the first dentition."

Sir Willliam Jenner says: "Children of the subjects of tuberculosis usually cut their teeth earlier, as opposed to rickety children, who cut them late."

Dr. Laycock says that in phthisical persons "caries most usually begins between and within the teeth, and most commonly in the laterals of the upper jaw."

Mr. Bell reported a case of a family of phthisical disposition the members of which all had phthisis, the father dying at thirty-six, and all had very pointed, almost hook-like teeth. This peculiarity, however, is not like the phthisical pattern, but more like that of syphilis, and in this family may have been the expiring effects of that vice, the phthisis being a sequel instead of a cause."

But the characters of phthisical teeth are now pretty well understood, so that, with other indications of the tuberculous tendency, they have some pathognomonic value.

Scurvy (*Scorbutis*).—Dr. Alfred Carpenter says: "Two centuries ago scurvy was a complete scourge in all the countries of Southern Europe, but the discovery of its cause has materially diminished its prevalence, although it is yet more frequent than it should be. It is recognizable in the minor form in which it appears amongst us both in the sick-room and among poor people in thickly-populated districts. Its first incidence is upon the gums: the teeth loosen; there is a tendency to hemorrhage and effusions of blood from mucous membranes; the slightest injury to the skin produces a bruised appearance. The cause is the absence of fruit and vegetables from the common diet of the sufferers. The effect of fresh fruit is to diminish those acids which result from the consumption of a flesh food which was too highly nitrogenous. . . . . Improper food in infant life does lay the foundation of disease in the dental appendages, which, following upon those produced by hereditary causes, is very serious in its results. . . . . It is possible that the teeth are the dépôts of deposit of the phosphate of lime which is formed in very minute quantities in the first months of fœtal life and before the bones are ready to receive, it may be, the débris of the nerve-cells which form in the infant. Let there be some defect in the innervation, such as would arise from a diet inducing scurvy, and we see the result in the defective character of the phosphate of lime which is deposited in the cells of the ivory and the enamel membrane of the new development. It is not a pure salt; it contains something besides phosphate; and as a result the cells are imperfect both in shape and number."

Dr. Flagg says: "In scurvy we have hemorrhages, spongy condition of the gums, etc., and if this diathesis prevails in infancy it will produce a defective dental organism."

Dr. J. H. McQuillen says that a very decided change of diet, as with the Irish on coming to this country, is often followed by the development of scorbutic and other affections injurious to the teeth.

Dr. Aitken gives as causes of scurvy "deficiency of absolute nourishment; improper assimilative powers of diet; bad quality of diet; bad cooking; pernicious influence of local surroundings, etc.; but the prin-

cipal cause is confinement to a specified diet, especially animal, and particularly salted meats, and the exclusion of fruits, vegetables, and vegetable acids. A scorbutic diathesis is often induced in dyspeptics by the gradual dropping of one article of food after another until but one or two remain, such as milk or milk and crackers, and those in insufficient quantity. The patient suffers from a slow starvation and becomes scorbutic. This cachexia may then be transmitted with its effect upon the offspring (DaCosta). Cases of scorbutis from insufficient food are not uncommon, arising from various causes—voluntary or forced fasting or insufficient diet. These may induce a scorbutic condition which, even if temporary and transient, may affect the offspring. It may exist at the moment of procreation or during pregnancy, and leave its mark upon the fœtus."

Arthritis, Rheumatism.—Dr. Dyce Duckworth, in an elaborate article upon "The Characters of the Teeth in Persons of the Arthritic Diathesis," says: "London appears to be the headquarters or centre of gout, and more true, unequivocal gouty disease is observed in this centre than anywhere else in the world. I believe that there is a basic arthritic habit of body or diathesis, and that from this issue at least two branches, the gouty and the rheumatic. These two are not convertible—cannot produce each other, but they may commingle. I will speak of the teeth in persons of the arthritic diathesis, rather than about the teeth of the gouty only. The primary dentition is usually satisfactory, and not different from that of healthy children. My experience is different from that of Dr. Alfred Carpenter, in that the teeth of gouty patients are not subject to caries. Amongst three hundred hospital patients who were the subjects of inherited gout in varying degree, I found the teeth were remarkably strong, well enamelled, enduring, and free from decay. Laycock taught this twenty-five years ago, as has his pupil, Dr. Jonathan Hutchinson, and also Mr. Coleman. I find the teeth are commonly large and regular in the arthritic diathesis; the edges are smooth in the permanent set, not serrated; there is a tendency for one or more of the incisor teeth in the lower jaw to be pushed forward, causing what Laycock called 'buck teeth,' but I do not think this is confined to this particular habit; the teeth are apt to rotate in their sockets in later life; children of this diathesis are apt to grind their teeth during sleep and persist in the habit to adult life, when it is done with such force as to chip and break the teeth; the enamel is usually yellow, white teeth being uncommon; the teeth are vigorous and firmly planted, and their extraction is difficult; the color is apt to deepen in tint, and the texture of the teeth is abnormally hard; the teeth are apt to wear on their articulating faces; there is a disposition to tartar, which often collects in large quantities; perfectly sound teeth are apt to be shed as age advances, as illustrated in several instances—one, a case of a young man of twenty-six—several becoming prematurely edentulous; carelessness in regard to cleanliness of the teeth or mouth or intemperance promotes tartar and caries; persons of florid complexion are more prone to caries, alveolar absorption, etc.; commingled diatheses—scrofulous, syphilitic, tuberculous, etc.—will produce corresponding effects; strumous taint appears to affect the enamel

materially, producing a tendency to caries, the teeth being irregular, ill-developed, serrated at the edges, and dingy in color.

"The character of the teeth in persons of *rheumatic habit* is certainly less remarkable than those which are noted in the gouty. The several tissues of the body appear to be less impressed by it, yet there is much similarity, and I recognize amongst the features of rheumatic inheritance the presence of strong, hardy, and well-enamelled teeth as the rule. This is not remarkable if it be true, as both the gouty and rheumatic predispositions spring from the great arthritic family. In each case, however, the intervention and modifying influences of cross-taint and mingled diatheses must be considered. Periosteal inflammation and pain are common in gout, as well as radiating neuralgia, etc. In America unequivocal gout is rarely seen, but rheumatism is endemic."

Dr. Alfred Carpenter says: "The effects of the gouty diathesis do not show themselves so markedly upon the teeth in early life as do those of the syphilitic and the tubercular states. It manifests itself in another way, and other tissues suffer more than the teeth, though caries is not uncommon. It is a disease of later life, so that the progeny of gouty persons are usually born before the humors have been affected in the parent. The constitution is not thoroughly gouty before forty, and men do not usually have many children after forty. So the children inheriting a gouty diathesis are rare; still, I think it is a fact that the teeth of such do decay early. This disease has its origin in fatty degeneration of the dental cells, and the subjects of it are especially liable to those peridental inflammations which ultimately lead to necrosis. Gouty persons also suffer from neuralgia and other conditions which have their origin in a lithic-acid diathesis, which is often accompanied by pain which reflects itself upon every function of the body. I do not yet know enough of the alliance between dental diseases and rheumatism to make any allusion to those tendencies."

Dr. Suesserott says: "The gouty affection is connected with dyspepsia, and is transmitted through the nerve-fibres, and its focal power is displayed in the peripheral nerve-fibrillæ."

Dr. Ord says: "Gout is a mode of decay of the whole system, marked by the deposit of urate of soda in and about the joints, tending to degeneration."

Dr. W. Stewart took casts of the teeth of eleven gouty patients. In all the teeth were thick and solid and worn down at the edges. Mr. Fothergill said these teeth had been first described by Dr. Laycock of Edinburgh. In the casts the teeth presented a resemblance that was unmistakable. They were all solid teeth. The wearing down was probably due to the presence of uric acid in the saliva. Mr. Sewill thought that, while the teeth were not pathognomonic, they were sufficiently pronounced to form an aid in diagnosis.

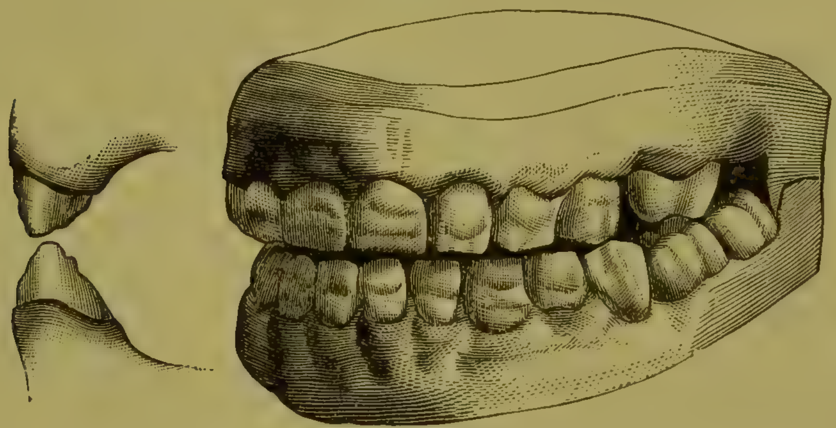
Dr. Horatio Donkin writes that "Dr. Grave as long ago as 1836 described the connection between grinding the teeth in sleep and the gouty diathesis, and explained it as being due to an irritable condition of the dental nerves. I know of eight children (the whole family of a father who has frequent attacks of gout, acute and seemingly acquired, and of a mother whose grandmother and mother suffered from the same

disease) who grind their teeth incessantly at night, and have done so all their lives. They all cut their teeth at an early age, having generally two if not four teeth at three months. In several of the children the teeth are worn. Some of them are also somnambulists and sleep-talkers; most of them are nervous, and some suffer from epistaxis. The eldest two have corneal ulcers. The teeth are characteristic."

In view, therefore, of the interesting scientific history given to this disease, especially in regard to its effects in producing teeth which are truly pathognomonic, it was with considerable interest that the writer discovered a case of gout in this country which is genuinely characteristic and which has an authentic history. The patient is now a woman of thirty or more, of arthritic diathesis, and anæmic from gout and rheumatism. The family is English, of course, for the case is imported and is not an indigenous product. Gout has been in both branches of the family for several generations, and the children inherit it directly. They have suffered from it from infancy, as this patient does yet.

Casts of the teeth of the case are herewith submitted, and it will be

FIG. 82.



noticed that the characteristics are pronounced. The teeth are short, thick in all directions, with heavy shoulders upon the lingual sides, and all very dark, solid, square, dense, and hard. The markings consist of transverse or encircling grooves or terraces, which give the teeth a step-like appearance. These grooves are perhaps characteristic, and are not to be confused with various kinds of grooves which mark the teeth affected by retarded development from different causes. The gums are light and thin, and present thin margins against the crown.

But it is only the anterior teeth that are attacked, and the bicuspids are but slightly marked. The first molars were presumably affected, but some of them are now absent. The other molars are normal and present no peculiarities of shape, but the history of an extraction as given by the patient leaves little doubt but that the teeth possess all the other characteristics, especially the difficulty of extracting, which is a regular accompaniment of the diathesis.

Very recently Mr. Milner Fothergill says: "There is little doubt but that the configuration of the teeth in gout has a distinct value. The teeth are solid, and in the 'Norse' type massive. They are blunt and thick at the edges and worn down. They have a great tendency to

come out without any caries, but from osteitis extending from the neck along the fang. The incisors are more worn down than the cuspids or molars are. The centre of the tooth is more of a dark color. When a gouty person shows the teeth, they are at once to be detected. The gum is much retracted. Sometimes the upper front teeth are very massive." This description can well be applied to the cast before us of gouty teeth in all characteristics—early wearing of the edges, the retracted gum, etc.

Dr. L. G. Noel has written upon the markings of chronic rheumatism upon the teeth which appear often after middle age, sometimes spoken of as "spontaneous" and "mechanical abrasion," but which he has found as accompanying rheumatism. It is a cupping of the articulating faces, and sometimes of the necks of the teeth on the external faces. But this is a secondary manifestation, and does not appear to be hereditary nor to affect the dental development of the progeny of these persons.

We have no evidence upon the characteristics of hereditary rheumatism upon the developing teeth. That there should be rheumatic teeth may be as probable as that there are gouty teeth, of which there is now no doubt. A close study and observation of hereditary rheumatics will undoubtedly reveal characteristic signs in the teeth.

Malaria.—The transmitted effects of malarial poisoning must have some deleterious influence upon the teeth. In the early pioneer days in the Western States "chills and fevers" were endemic, and the influence of the transmitted malarial constitutional condition had an influence that left its mark upon the population. This influence depressed the physique and evolved a sort of "aguish diathesis," if the coinage will be allowed. This peculiar constitution had its dental characteristics, which were a more or less coarse, soft, roughly-made tooth, with soft gums disposed to inflammations. We meet such dentures among the backwoods natives of the Mississippi Valley, who have developed a constitution acclimated to the malarious climate in the great basin drained by the Mississippi and its tributaries.

(2) Infantile or Acquired Diseases.—Under this head we will need to consider those diseases which are accidental and acquired after birth, and are quite independent of congenital causes. These are the diseases of infancy which have or may have an effect upon the developing teeth by modifying nutrition or the formative organs. The most important and influential of these are the exanthematous diseases, and after them the nervous lesions incident to childhood.

The *exanthemata* seems to affect the enamel most (Flagg), on account of their relation to the skin and epithelium and their disposition to attack the parenchyma of organs. Mr. Salter states that he considers that in the eruptive diseases the *materies morbi* affect the teeth by virtue of their being members of the dermal or tegumentary system, upon which the poisons of the eruptive fevers spend their force. Dr. Richardson does not think so, but gives it as his emphatic opinion that, excepting smallpox, there is no proof that any of the eruptive fevers produce affections of the teeth.

All of the infantile diseases, smallpox excepted, may occur during

the formation of the permanent teeth without affecting them. These diseases sometimes cause necrosis and exfoliation of the separable inter-maxillary bones in childhood, along with the contained teeth. Cases are on record of smallpox, scarlatina, and measles being followed by exfoliation of the jaws or parts of them and the accompanying tooth-germs.

The exanthemata, however, modify the growth of the teeth and occasion markings, as erosions, pittings, atrophies of various kinds, and, indeed, simulations of the signs of the great constitutional vices. Very few of them have markings which can be considered in the least degree pathognomonic or characteristic. The defects they induce are irregular and uncertain in feature.

Variola.—The evidence is conclusive, as adduced by all writers upon the subject, that smallpox may affect the development of the teeth very seriously. Even the writers who question the influence of eruptive fevers in general make an exception in the case of smallpox, admitting that it may sometimes mark or mar the teeth. In well-observed cases it seems to have been the cause of erosions—of no definite character, indeed, but of destructive effect. Pitting, atrophy, asymmetry, and other defects have originated from it. Exfoliation of the germs, also of parts of the maxillaries, has occurred. Its effect upon the internal structure of the teeth has not yet been investigated. When combined with a strumous or scrofulous or other vitiated habit of course its effects are intensified.

Scarlatina.—The gums and mucous membrane of the mouth not being much affected by this disease, there is some uncertainty, if not doubt, as to scarlatina having any effect upon the teeth. Little is recorded of observations upon the subject, nor do writers give a favorable opinion of the possibility of such sequelæ. But as osseous and neural lesions, as well as epithelial, often follow as sequelæ, it is highly probable that the developing tooth will be impressed, and that with a diagnostic feature distinct and pathognomonic. Mr. Napier, indeed, claimed that in a case where the semilunar notch was developed this defect was due to scarlet fever and not to syphilis. Mr. C. Spence Bate maintains that carbonic acid is the cause of caries, and that it is developed where there is derangement of the blood, especially in such diseases as scarlatina, when there is excess of carbon in that fluid. The eruptive character of the disease, besides, will have its effect upon the enamel in characteristic markings when these are made out.

Measles sometimes gives rise to a form of defect called the "measles tooth," described by the first observer, Harrison Allen, M. D., as of narrowed width, having a compressed, eroded edge, with vertical grooves or flutings on the lower half. This is best observed on the incisors. As the buccal mucous membrane is early, if not first, attacked by the eruption, it is likely that the teeth are pretty constantly affected, especially in the severe forms in predisposed diathesis. Measles sometimes causes exfoliation of tooth-germs as well as of the jaw (Bressler).

Varicella may affect the developing teeth. As the eruption appears upon the oral mucous membrane and its appendages, we can conceive of the dental germ being affected. No recorded cases have, however,

come under our observation. The writer has seen a case where a severe and dangerous attack of chicken-pox was sustained at one year old. The incisors and first molars of the permanent denture were eroded: while the coincidence is not evidence, the case is worth recording.

Stomatitis.—While not specifically a primary disease, stomatitis follows in the wake of other lesions as a cause of maldevelopment. Syphilitic stomatitis, Mr. Hutchinson thinks, is an active cause of the destructive effect of that vice. But a stomatitis of any kind will affect development. Its force is usually displayed upon the upper incisors, although its effects often extend to the lower incisors and to all the cuspids. It causes the teeth to have a dirty or dull brownish appearance, and to yield quickly to decay. Mr. Hutchinson attributes to mercury a chief place as a causative of stomatitis, and says that defects of the teeth usually result from attacks of inflammation of the gums in early infancy. The first molars are the subjects of mercurial stomatitis, but other disturbances causing stomatitis simulate mercury in their effects. Mercurial stomatitis is very like any other stomatitis.

Intestinal Disturbances.—M. Magitot has related an interesting case where "dental erosions were caused by chronic enteritis. The incisors, cuspids, and first molars were in a state of complete disorganization, as in the form called 'honeycomb.' The seat and extent of these lesions of the teeth offered a precise connection with the invasion and the long duration of the enteritis, which, having begun in the second month, was prolonged to the second year. The second and third molars, the evolution of which occurs after the second year, presented no alteration whatever." The intestinal disturbances frequently occurring during dentition, as well as those arising from other causes, often cause grave alterations in the forms or quality of the teeth. This has been noted by many writers, but none of them have given us any forms of defect which may be considered pathognomonic. Many of the common forms of erosion have been known to be occasioned by this class of diseases.

Eclampsia.—This is the most active and prolific of the nervous diseases affecting development. The nervous system and the nervous tissues being so closely related to the teeth, a disturbance of the former so serious as this disease readily affects the development of the dental organs. Arlt observed that convulsions in infancy were usually associated with lamellar cataract, and Mr. Hutchinson believed that that would explain the defective teeth associated with cataract, for the connection between fits and cataract is almost universal, and with defective teeth very constant. In seventy-eight cases observed by Prof. Horner there was a history of convulsions in 76 per cent. of these, and deformity of the teeth in 85 per cent. Accidents, falls, and blows upon the head in infancy may produce convulsions, but these do not affect the teeth. Mercurial teeth are often associated with convulsions, mercury being given in quantities for that lesion.

M. Magitot holds that erosion is largely due to eclampsia. He found that "forty cases of erosion had all presented in their infancy symptoms of eclampsia, without any other malady to which could be attributed the lesion of the dental system. He could in many cases establish a correlation between the age when the eclampsia occurred and the level of the

crown where the erosion took place. Now, we go farther, and from the level of the notch or the furrow we name the date of the convulsions. It seems incontestable that infantile eclampsia can be the cause of erosion, and that it marks upon the dental crown the date of its appearance." M. Fournier dissents from this, and attributes to syphilis all that M. Magitot claims for eclampsia in causing erosion.

Insanity, Lunacy, and Feeble-mindedness.—We have no direct evidence that these lesions produce disturbances of a specific type, except so far as they affect physical development. The tooth-germ may indeed be influenced by them, but no connection has yet been noticed. When any alteration of the mental condition comes as a sequel of exanthematous diseases, the effects produced upon the teeth are the legacy of the latter, and bear relation to the mental aberration only as a correlative result. Idiots sometimes possess a prominent and hypertrophied incisor or cuspid which looks like a tusk. But this too may result from syphilis or other constitutional lesion, and be only an evidence of the latter. Defective teeth, which are soon lost by caries, usually accompany idiocy, as does also a vaulted, narrow palate in many cases. The effects of congenital idiocy and inherited nervous diseases have been noticed under the head of Nervous Disturbances.

Puberty.—While not a disease, the stage of puberty gives rise to so much nervous aberration as to affect the quality of the permanent teeth which have not completed their formation at this age. The teeth most affected are of course the third molars, and much of this defectiveness—for they are always inferior in quality to the other teeth in the same denture—may be due to the disturbances of puberty affecting the nervous centres presiding over the development of the teeth. Of course, if the process of transition were normal, puberty would be physiological and produce no disturbance. But with the general nervous eccentricity of civilized life, puberty, with other processes, is abnormal, and, being abnormal, disturbances arise from it which affect the physiological condition of the entire system. One of the pathological phenomena is an aberration of the growth of the wisdom tooth, as it crowns the effect of the growing years of childhood upon this tooth.

Nasal Catarrh.—Proceeding to miscellaneous disorders, we find this of some importance. Prof. Harrison Allen has given us some excellent observations upon the subject. He says: "Chronic catarrhal states in childhood are invariably associated with other effects of malnutrition. These errors in development are conspicuous in bone, tooth, lymphatic, and nerve tissues. . . . . With chronic nasal catarrh errors of development of the teeth and rates of growth and nutrition of the nails are often associated; but in pathology the relations between the hair, nails, and teeth are numerous. Abnormal development of the teeth occurs in congenital hypertrichosis. . . . . I have frequently found defective teeth associated with white spots on the finger-nails in many forms of disease affecting the growth of the tegumentary structures. In catarrh this is often marked in the association with dental defectiveness and with retarded or interrupted eruption, and sometimes complete absence of teeth on to adult age. Milky opacities of the enamel occur as one form of the defect accompanying it."

Whooping Cough.—Atrophied teeth sometimes result from severe attacks of pertussis. The nutrition is impaired, and cases are recorded where, after softening of the enamel, the dentine would turn green and cheesy and an ulcer would be found at the apex of the root on extraction (Seymour).

Tonsillitis.—Mr. Charles Tomes speaks of persons who have from childhood suffered from enlargement of the tonsils, and are consequently obliged to breath through the mouth. This being pretty constantly open, causes a slight increase in the tension of the lips at the corners of the mouth, and is impressed upon the alveolar arch as an inward bending of the bicuspids at this point. Thus, persons with enlarged tonsils will be found, almost invariably, to present one of the forms of V-shaped arch and the evils of mouth-breathing. Caries of a peculiar form occurs as the result of constant exposure to the atmosphere.

Cataract.—Mr. Jonathan Hutchinson says that "although it has been well known that children suffering from cataract have usually badly-developed teeth, the malformation has been variously ascribed to congenital syphilis, rickets, or general defective development." He believed that imperfect teeth are, as a rule, met with only in connection with one form of the cataracts of childhood—viz. "lamellar" or "zonular" cataract. It is unassociated with any special diathesis, and is rarely met with in more than one member of a family, and is not recognizable in the eye until the child is a few years old. The defect in the teeth consists mainly in defective development of the enamel rather than in alteration of the form of the teeth. It is often associated with syphilis, but must not be confounded with it. The incisors, cuspids, and first molars suffer most as a rule, and with but very few exceptions the bicuspids escape entirely. The contrast between the clean, white, smooth enamel of the latter and the jagged, discolored, spinous surface of the first molars is often very striking. The first molars form the test teeth for this condition, as the upper centrals do for the syphilitic. It occurs equally in both jaws in these teeth, and sometimes they alone are affected. The permanent alone exhibit changes which can be relied upon for diagnosis. The incisors and cuspids are pitted, dirty, and broken, often presenting very sharp edges, sometimes almost spinous. In some cases a horizontal line crosses the crown of the incisors and cuspids at one level, the part of the tooth below being narrow from before backward, sharp, and broken. Non-development of the enamel and erosion of the exposed dentine appear to be the essential features. In the first molars it is usually the surface alone that is affected, the sides of the crown being often covered with good, smooth enamel, while its surface is denuded, brown, and ragged. The coincidence of these teeth with lamellar cataract is not, however, constant, for the one often exists without the other; hence he concluded that there was no direct correlation between the nutrition of the lens and that of the permanent teeth to cause the coincidence. He thought with Arlt that there was usually a history of convulsions in early infancy in cases of lamellar cataract, and believed that therein might be found the explanation of the dental condition. While often associated with rickets, cataract was not necessarily caused by that disease. Prof. Horner found it associated in only 4 per cent. of 78 cases observed.

In concluding this portion of our subject we can only say that, while not agreeing with many of the writers, we have given all the obtainable evidence on each subject in order to be as full as possible, our object being merely to present as complete a compilation as our literature will permit, and not attempt the defence of any theory.

(7) Drugs and Artificial Diseases.

Under this head we notice the effect upon the development of the teeth of pathological conditions induced by the toxic effects of powerful drugs. These may be administered by the physician or be constantly employed by the individual for the effects that may be induced. To these must be added abnormal conditions induced by pernicious habits without the use of drugs.

Mercury.—The effects of mercurial poisoning upon the teeth has been dwelt upon at length by many writers, some of whom attribute as much evil to it as to syphilis itself in causing defective development. Amongst the mercury-mines of Idria, for instance, diseases are induced which cannot be distinguished from the venereal, and children born of these people are scrofulous. Mr. Hutchinson thought that mercury held the chief place as a causative of stomatitis, in that it was given in large doses in convulsions as well as being an ingredient in most teething-powders. He thought that malformed teeth were often evidence that the patient had taken mercury in infancy when the enamel was undergoing calcification. Where cataract and convulsions and defective teeth are found together there is usually a history of treatment of the fits by mercury.

Mercurial markings might be seen in connection with the syphilitic, or might not appear at all unless mercury was given in quantity. They are usually seen in one member of a family and associated with a history of convulsions. As a principal ingredient of all teething-powders and as given during the various disturbances of dentition, mercury certainly is a valuable remedy at this period for the treatment of disease, by reason of its quality of accelerating the evolution of the teeth. But if the drug causes deformity and imperfect development of the teeth, its use is not an unmixed good. The "mercurial tooth" consists essentially of an absence of enamel, and is most evident in the first molars. The dentine runs up through in the form of turrets. The bicuspids are always sound; the incisors and cuspids are generally deficient in enamel, dwarfed, yellow, with wide spaces between. These mercurial teeth, as described by Mr. Hutchinson, he has often seen associated with the notched incisors of inherited syphilis (Burnett). Mr. Salter does not believe that the first molars are peculiarly susceptible to mercury, but he thinks that cases are rare where mercury produces stomatitis in children, and that the deformed teeth called "mercurial" appear in all nations whether mercury is administered or not, and that years ago, when mercury was used more frequently and freely, "rocky" teeth were not more frequent. Mr. Hutchinson states that the broad difference between syphilitic and mercurial teeth is that the former exhibit atrophy in every way, but that mercurial teeth present no general atrophy, little malformation, and only an absence of enamel, allowing

the dentine, which is dark and spinous, to project through. This denudation and the dirty-looking, ragged surface are more apt to attract attention than the more important syphilitic malformation, and are often confounded with the latter. Very often there is a history of convulsions which had been treated by a large quantity of mercury. With convulsions lamellar cataract is often associated. The general result of his inquiries has been that there is a connection between the use of mercury in infancy and this defective dental development, admitting at the same time that any other cause of stomatitis will produce the same result. There is nothing by which the dental results of mercurial stomatitis may be distinguished from those of any other kind of stomatitis.

Tobacco.—Exactly what the effects of this drug may be upon transmission we do not know; but, as it induces a vitiated constitution of a depraved type, inheritance will certainly carry some vitiated condition into the next generation. A physical degeneracy will be induced which will have some effect upon the teeth, directly or indirectly. The toxic effects of nicotine are manifested in derangement of various organs and alteration of tissues, and the vice transmitted will affect the quality at least of the dental tissues. As it tends also to retard the development of tissues and normal growth, its inherited influence might be felt in this way by the growing teeth. As it causes congestion, recession, and absorption of the gums and alveoli in the habitual user, these abnormal conditions may be transmitted and have a corresponding effect upon the supporting environments in development. The sluggish condition induced will also affect development more or less distinctly and induce stunted teeth at least.

Alcoholism.—The constitution undermined by the alcohol habit transmits a variety of evils. Much of the congenital lunacy, as well as epilepsy and other nervous lesions, found in our asylums originates in a drunken parentage. Physically, it induces only deterioration and disease and a variety of weaknesses which are reflected in the teeth. It is a source of idiocy and of idiotic teeth, such as the enormous tusks of microcephales. Physical dwarfing sometimes occurs, and cases are noted by Langdon Down of permanent infancy. These latter are procreated during alcoholic intoxication. The offspring of parents with chronic degeneracy from alcohol are different, and inherit diseased organs which modify the circulation and nutrition. As it ravages the other tissues of the body, the toxic effect of alcohol produces also a degeneration of the teeth, but of what character we cannot yet pronounce. Affecting the membranous tissues as it does, the developing tooth must be influenced, either by the thickening or thinning of membranes and tissues incident to alcoholic saturation, whereby the pabulum is either lost too rapidly or effete matters are retained. The organs are thus directly injured and the blood is rendered foul, poisonous, and unfit for the construction of normal organs.

Opium.—The abuse of this drug by nurses and ignorant mothers in its reckless administration to infants is an evil that leads to much infantile weakness, disease, and death. It is possible that its employment upon the nipples by conscienceless and indolent nurses when nursing the

children of the rich may have much to do with the mental dulness and physical degeneracy of such children. Certain it is that the deplorable use of the villainous compounds known as "soothing" and "teething" syrups, which contain impure opium in irregular quantities, does produce physical and mental weakness and disease. This weakness cannot but be reflected in the teeth by a degenerate organization, the type of which we cannot yet determine. Then, again, the habitual use of the drug produces a type of physical degeneracy which affects the offspring of such persons. What the type of teeth produced by this inheritance may be we have yet to learn.

Vaccinia, as a cause of irregular and imperfect development, is not perhaps of much moment of itself. If the disease induced has any effect upon the follicle, we have little knowledge of it. As a vehicle for conveying syphilis, however, vaccination is much to be dreaded. There are many authorities on both sides of this question, but the possibility of inoculation is enough to frighten conscientious men. Then, again, vaccination may arouse dormant taint and cause a profuse eruption, the caused assigned by parents being "impure lymph," while the real source is in the impure system inherited. But vaccinia, by combining thus with latent syphilis or scrofula, may occasion an excessive disturbance and disease which may affect the teeth permanently.

Mr. Albert Carter suggests that "vaccination itself may be at the root of the defective dental organization so prevalent where European physicians practise, and nowhere else. A bovine disease is introduced into the blood of the infant, and its constitution becomes thoroughly under the influence of it during the earliest stages of the dental formation, causing that defective development from which the present generation so generally suffers."

Thumb- and Tongue-Sucking are causes of some forms of irregularities and malformation of the jaws when persisted in for a protracted period in infancy. "Many mouths are deformed by a mistaken indulgence in this injurious habit of infants by parents or nurses, and the deformity is a most troublesome one for the dentist to deal with. Besides the pressure of the upper teeth forward and the lower teeth backward, they carry with them the alveolus, deforming the arch. The force of sucking contributes more force, which lengthens the upper and shortens the lower jaw" (Quinby).

Dr. T. H. Chandler says that "thumb-sucking produces a peculiar hollow in the palatal bones just back of the incisors, fitted to and moulded by the thumb. The front teeth are projected forward and spread out like a fan sometimes, but commonly at an angle overlapping one another and pushing out the upper lip, giving the face a prognathous expression, the whole upper jaw having a stretched, hard look; the bone of the floor of the nares becomes elongated and narrowed, thus causing mouth-breathing and its attendant ills, greenish tartar being one of these. In the lower jaw an opposite condition obtains: the lower teeth are pushed back, the jaw flattened and shortened, protruding at the sides, with corresponding derangement of the articulation. The rami while soft are literally bent back, throwing the bite backward the diameter of a tooth, the lower incisors coming up to the gum behind

the upper incisors. For this kind of irregularity little or nothing can be done. As the permanent teeth erupt, each successive molar takes all the bearing, until finally only the wisdom teeth strike and keep the other teeth apart, entirely preventing mastication, interfering with speech, and injuring the looks seriously. The injurious effect upon the wisdom teeth soon causes their loss, then that of the second molars, then the first molar, and so on until the denture is ruined. And all this because of the indulgence of a pernicious habit in infancy when carried to excess." Finger-sucking is also practised with much the same injurious results; lip-sucking, tongue-sucking, either in front or on the sides, with corresponding deformation, the teeth and bones being deeply impressed. These practices being allowed to go on at all hours of the day and night, the continual pressure cannot but deform the parts against which the muscular force is exerted, aided by the force of sucking and atmospheric pressure. "Sugar-teats" may be injurious in the same way, in addition to their destructive fermentative effects upon the teeth and digestive tract.

The sucking of other articles—toys, clothing, etc.—may be equally injurious. The practice should be broken up as soon as discovered and before it becomes an inveterate habit too difficult to cure.

Accidents and Injuries to the face and jaws during the development of the teeth often cause injury to the tooth-germs which leads to deformities and imperfect products. A crown may thus be bent at an angle with the root, or be stunted, or broken and reunited, or part be destroyed altogether, or the entire tooth-germ be annihilated. The possibilities of deformities which may thus arise from forcible injury of the region containing the growing tooth-germs are infinite and indescribable. Many permanent imperfections of form or structure, of arrangement, or of the supporting tissues have been noticed as proceeding from accidents in childhood.

Injuries to the head which produce convulsions do not have any deranging effect upon development. Those which impair general nutrition may have such an effect, however.

Conclusion.

In epitomizing the whole subject, which we have elaborated at so much length, we may conclude that the one great cause of dental degeneracy and defective dental tissues, whatever the seeming antecedent, is *physical degeneracy*. Occupying the position of organs peculiarly susceptible to alterations of nutrition, they quickly report any deficiency or impairment of the nutritive supply either in quantity or quality. The causes of the impairment we have attempted to classify and describe with some minuteness as well as comprehensiveness, but fail, of course, of covering the whole ground or of giving a complete résumé of the subject. One of the principal difficulties to be encountered in the work is the scarcity of recorded observations and of systematic investigation. It is a field of wonderful richness, inviting and challenging the physiologist and pathologist to enter and reap the reward of brilliant discoveries in store for them.

ANOMALIES OF THE TEETH AND MAXILLÆ.

By S. H. GUILFORD, A. M., D. D. S.

Anomalies of structure and development are found in every portion of the human system, but in no part are they so common or so diversified in character as in the teeth and the jaws. They possess interest in themselves as being variations from the normal type, but greater importance is attached to them when considered in relation to each other and to the conditions influencing or attending their existence.

Anomalies are seldom met with in the deciduous set, and such as occur consist principally in the coalescence of two or more teeth or in slight irregularity of position. In the permanent set deviations from normality are quite frequently encountered. These will be most conveniently considered under the headings of number, arrangement, size, structure, and eruption.

Anomalies of Number.

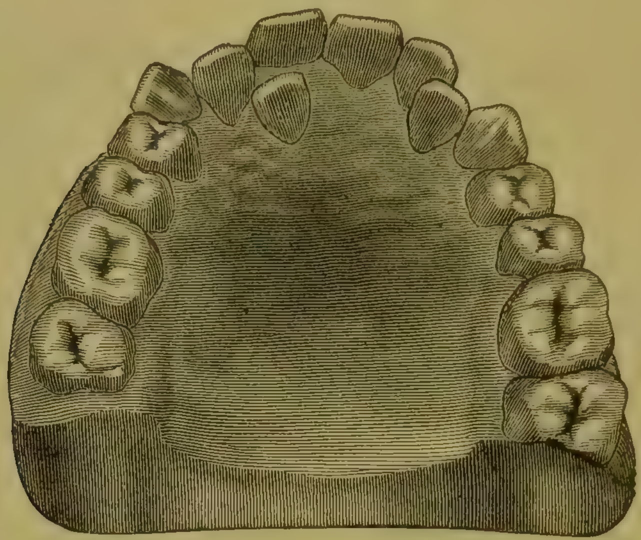
The deciduous set consists of twenty teeth—four incisors, two cuspids, and four molars in each jaw, while the permanent set consists of thirty-two—four incisors, two cuspids, four bicuspids, and six molars in each jaw. This number may be altered either by excess or deficiency.

Excess of Individual Teeth.

Teeth over and above the normal number are generally known as supernumerary teeth, and may be divided into two groups, according to their form. One group comprises those that are normal in size and form, and are thus easily referable to the class to which they belong; the other group embraces those that are of unusual form and do not closely resemble any of the normal teeth. The supernumerary teeth of the first group are found as incisors, bicuspids, or molars. Cases are quite common where five incisors have been found in the lower jaw, all occupying a regular position in the arch, and some writers mention having found six incisors thus normally placed. In the upper jaw the supernumerary incisors are usually laterals. Sometimes there is but one, occupying its place in line beside its fellow, but often there are two, occupying places inside the arch and in close proximity to the normal laterals. Fig. 83 illustrates a case of this kind, the model of which is in the

writer's possession. Coleman illustrates a case of seven teeth placed between the cuspids of the upper jaw. Four are large, well-formed centrals, two are laterals, while the third is probably a deciduous tooth

Fig. 83.



still remaining. Three bicuspids are sometimes found in one of the dental segments, but the same condition rarely relates to both sides of the same arch. In such cases the extra tooth will generally be found to be inside the arch and lying close to the two in line.

In rare instances a fourth molar will be found on one or both sides of the jaw, but Wedl mentions the case of a negro who not only had four molars on either side of each jaw, but in addition a supernumerary bicuspid in the lower jaw, thus making five teeth in excess of the normal number.

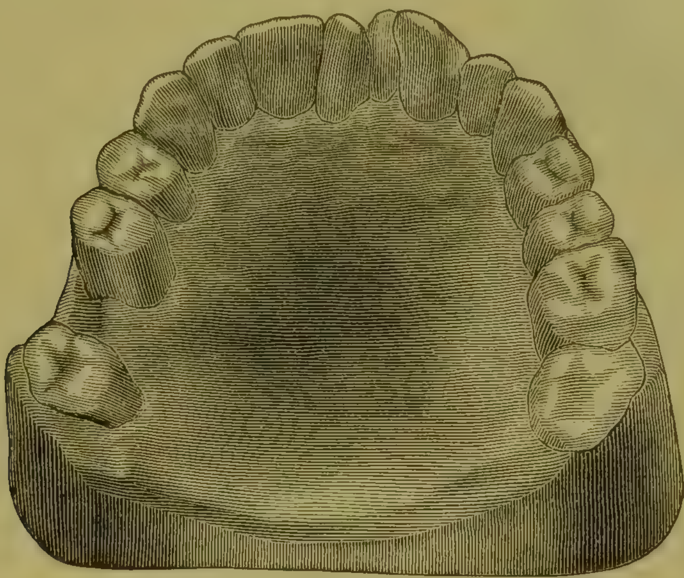
In the second group of supernumerary teeth, composed of those of unusual form, the additional teeth are usually small in size and conical in shape both in respect to root and crown. When the crowns do not take the form of a single cone, they are mostly made up of a series of cones or denticles surrounding a central cone. (See Fig. 84.) These conical supernumerary teeth are most frequently found in the incisor region of the superior arch. In many cases a tooth of this class will be found occupying a place between the central incisors, but more frequently they are found to occupy the places of the lateral incisors; which position, unless removed, they will maintain through life. Whether in the latter case they are developed from the germs of the teeth whose places they occupy, or whether they are developed independently of them, has not been fully determined; but from the fact that if extracted they are seldom if ever succeeded by the normal teeth, we are led to infer that they are anomalous developments from the original germs. For this reason it is unwise to extract them.

Fig. 84.

When these teeth do not occupy a position in the arch to the exclusion of normal teeth, but are simply interposed between them, the question of their extraction or retention will have to be decided by attendant circumstances. If discovered very early, during or soon after the erup-

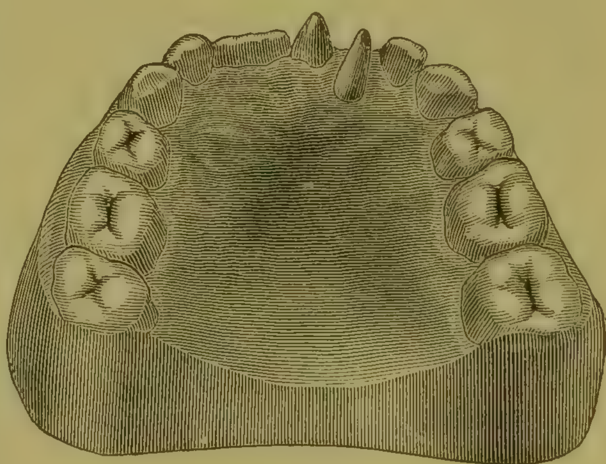
tion of the other permanent teeth, they should be extracted, for then the space that they occupy will soon be closed by the approximation of the adjoining teeth. If discovered only after the maturity of the individual, they may, if not too unsightly, be retained with advantage. In the latter case they can frequently be so shaped with the file or corundum-wheel as to nearly resemble one of the adjoining teeth. If, however, their position is such as to cause one or more of the normal teeth to be forced

Fig. 85.



out of position or rotated on their axes, as is frequently the case, they should be removed, since to retain them would simply be to confirm the irregularity they were instrumental in producing. So, too, if found situated anywhere but in the arch, whether without or within, they should be removed, since they will prove an impediment in articulation, be productive of inharmony of the features, or, if lying in contact with other teeth, be promotive of decay. Figs. 85, 86, after models in possession of the writer, illustrate two effects of their presence. In the former, two supernumeraries separate the normal teeth; in the latter, the adventitious tooth also causes torsion of one of the centrals.

Fig. 86.



Instances of duplication of certain teeth after the loss of the original are extremely rare. The writer has met with but two in the course of his reading. Wedl relates a case, mentioned by Heider, where a woman lost a permanent cuspid: in its place there appeared shortly afterward a dwarf tooth about the size of a grain of rice; this was succeeded by

another and still another of the same size. This cannot be counted a case of duplication, strictly speaking, for the later teeth were evidently only dwarf supernumeraries. Fig. 87 represents a case of supposed duplication, as given in the *Dental Cosmos*, vol. xxv. p. 615. In the description of the case the writer states (on the authority of the parents and of an older brother of the patient) that at the age of fourteen the patient lost his two permanent central incisors by a blow. These were succeeded by the normal left central and supernumerary, as shown in the cut. Later, a prominence having developed over the region of the anomalous tooth, the latter was extracted and the right central came in to occupy its normal position. "Here," says the writer, "is a plain case of the fourth tooth being erupted in the same spot." As the statement that the two teeth lost by the blow were permanent teeth rests solely upon the authority of non-professional observers, it is altogether probable that the teeth lost belonged to the deciduous set, that these were succeeded by a normal central and a malformed tooth, and that the latter was in time succeeded by the delayed permanent right central.

Fig. 87.

Lack of Individual Teeth.

Absence of certain teeth in the dental arch is of very frequent occurrence, but such absence need not indicate any anomalous condition. Missing teeth may have been extracted, and the fact not be remembered by the individual, or they may have been removed under the misapprehension that they belonged to the deciduous set. So, too, the missing tooth may be imprisoned, and thus be incapable of eruption, or the eruption may be prevented by a retained deciduous tooth. Instances of each of the circumstances just mentioned are so numerous that it is exceedingly difficult in many cases to decide upon the cause of the absence of one or more of the permanent teeth.

That the germs of certain teeth are either totally destroyed by accident or disease before development, or are so modified and influenced as to develop into abnormal teeth, is entirely probable; but, while this may occur, and doubtless is the cause, in many cases, of the absence of certain teeth, still we think that the majority of absences may be accounted for by the causes first enumerated.

Cases of genuine lack of number are frequently hereditary, the peculiarity being transmitted from parent to child. The teeth most frequently found missing in the permanent set are the superior lateral incisors. Cases of this kind are very numerous, and the space caused by their absence or the approximation of the centrals and cuspids is a deformity readily noticeable. Sometimes, though rarely, one of the

cuspids is never erupted, and in like manner a patient may be lacking one or more of the bicuspids or molars.

Instances are not wanting in which the individual had but one or two incisiors in either jaw, and indeed where the entire number in both jaws did not exceed the normal number for one denture. Such extreme cases of lack of number can generally be accounted for on the ground of heredity; often they are to be found in connection with other abnormalities of the hair and skin.

Multiple Dentition.

The question of the occurrence of a third dentition has been and probably will continue to be a mooted one. Several such cases have been reported by different writers, but when we make due allowance for errors of observation, for hearsay evidence, and for the magnification of a few teeth into a complete set by interested and unprofessional relatives, the number of plausible cases will be reduced to a minimum. Those who deny the possibility of such a condition have been led to their opinion by the paucity of cases reported, by the unauthentic character of such reports, and by the fact that the authenticity of several cases so reported has been disproved by careful investigation. The possibility of a third dentition is seldom denied on theoretical grounds, but its actual occurrence is doubted by many whose opinions are of great worth. The writer has never seen such a case, although he has often heard them reported.

Imprisoned third molars or other teeth erupting a long while after the removal of the balance of the set may easily be mistaken for members of a third set, and the few soon become an entire set after a few times relating. Aristotle, Eustachius, and Albinus mention repeated renewals of teeth, while Hufeland describes a case within his own knowledge. He says that the patient at the age of one hundred and sixteen years erupted a number of new teeth, and that six months after the removal of these several new molars appeared in each jaw.

An interesting case of multiple dentition is related in the *Southern Dental Journal* for October, 1886, by Dr. B. H. Catching, the editor. The patient had been a patient of Dr. T. T. Moore of Columbia, S. C., and afterward became a patient of Dr. Catching of Atlanta, Ga. Both of these gentlemen, together with other dental practitioners, have seen the case from beginning to end, and carefully observed the conditions and developments, so that in this case, at least, there would seem to be no room for false observation or for inaccuracy of record. The patient, Julia W——, was born Aug. 6, 1871. She was very small and delicate, being a child of premature (six months') birth. Her parents were strong and healthy, with no hereditary taints. At the age of six months she began teething, and at seven months had a full set of small teeth. All of these were shed within three months, and when eleven months old she began cutting teeth again, so that at the age of fifteen months she possessed a second full set. These soon crumbled away, and she was without teeth until two and a half years of age, when her third set began to appear. At this time she weighed but ten pounds. This

third set caused her so much trouble and annoyance that the mother tried to induce her dentist to extract them. Failing in this, she secured a pair of forceps and herself extracted twelve teeth of the set to afford relief to the child. All of this third set were removed before she was four years old. She was then edentulous until eleven years of age, when she began cutting her last and permanent set, nearly all of which are in her mouth now, sound and firm. This permanent set lacks six of being complete—viz. one superior central and one superior left bicuspid, two inferior right bicuspids, and an inferior left cuspid and bicuspid. At seven years of age the child weighed only thirty pounds, but since then her health has improved, and she is to-day, at the age of fifteen, a stout, strong girl budding into womanhood.

Lack of Dentition.

Reported cases of total absence of teeth are even more rare than those of multiple dentition. Not only are they few in number, but they are reported with such a lack of detail as to leave the reader unable to judge with any degree of satisfaction as to the correctness of the testimony in respect to them or as to the possibility of erroneous observation.

While all writers seem to agree as to the possibility of such a condition, several doubt the probability of its occurrence. In this, as in other cases of anomalous dentition, the record, to be of any scientific value, should be based upon careful professional examination, coupled with the testimony of reliable and disinterested persons familiar with the case from childhood up, and, if possible, the hereditary antecedents.

Linderer mentions the case of a woman of fifty who never had any teeth. J. Tomes mentions the recording of two cases, one by Boxalli and the other by M. Baumes, in which the patients had reached old age without a single tooth ever having appeared. He (Tomes) says that in his own practice he has never met with a person who did not present some indication of second teeth. Carabelli never observed an edentulous case, and asserts that the entire absence is an improbable though not an impossible occurrence. Heider says that in a practice of twenty-three years he never met with an instance of total deficiency.

The writer has met with a most marked case of this character in his own practice. The patient, Peter Wendling (now residing in Lebanon, Pa.), is over fifty years of age, in perfect physical health, a cobbler by trade, and the father of eight children. Besides having been edentulous from birth, his sense of smell is entirely lacking and his sense of taste very nearly so. Although he wears a beard and has a normal growth of hair in the axillary and pubic regions, his head has but the slightest growth of short, fine hair upon it, and the rest of his body is totally devoid of the fine surface hairs normally present. Coincident with this there are no pores in his skin, or if present they are inoperative, for the man has never perspired in his life. His jaws do not differ in appearance or form from those of any individual whose teeth had been extracted years before, as is well shown in Figs. 88 and 89.

The hereditary features of the case are most marked. Mr. W.'s maternal grandmother never had either hair or teeth. Her daughter,

the mother of the patient, was normally developed, but she had a brother who was edentulous and hairless from birth. Mr. Wendling's mother was married at sixteen and died at forty, and in that time gave birth to twenty-one children. Some of the births were premature and several were twins, but eighteen lived to maturity. Mr. W. was not the last of the series, though one of the later born. He was the only one who was edentulous, though some of his brothers lacked certain teeth. None of his children inherited his peculiarities, excepting that some of them were without their full complement of teeth. Two of them, girls, aged respectively fourteen and sixteen, were examined by the writer, and their jaws were found to contain only about one-half the normal number of teeth. All of the cuspids were present and certain of the molars and bicuspids, but the set of incisors was

FIG. 88.

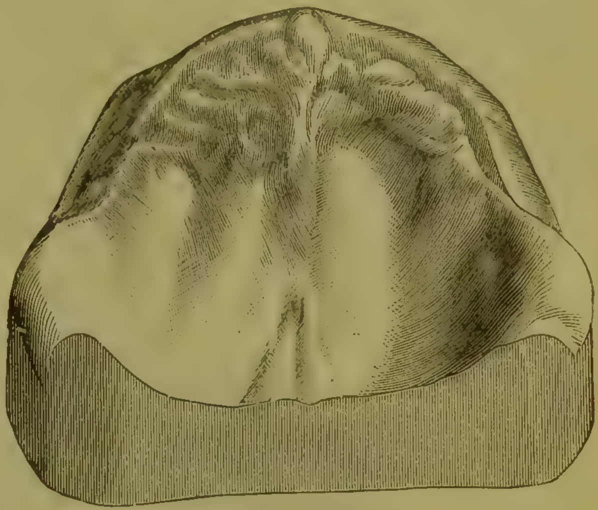
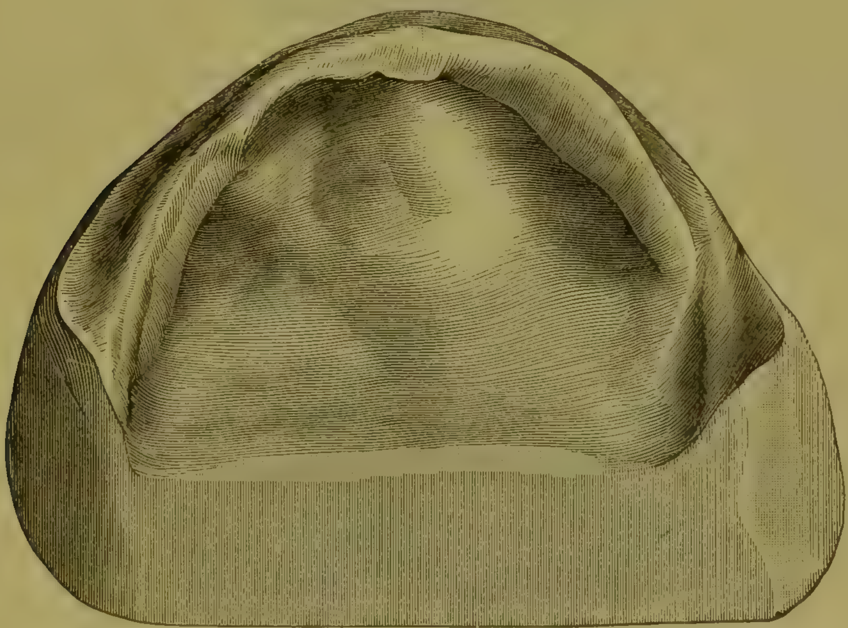


FIG. 89.



represented by but a single lateral in each jaw. The statements of the patient were verified, and the facts in regard to ancestry were obtained from his eldest brother and from an intelligent elderly couple living at the place of his birth, who had not only known him from childhood, but had been well acquainted with his edentulous uncle and grandmother.

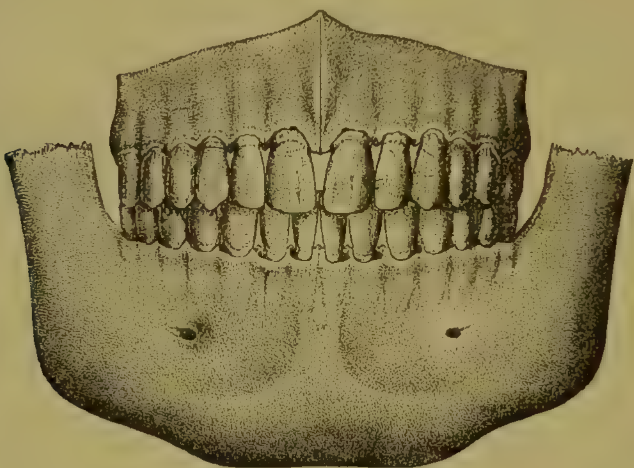
The writer had the pleasure of exhibiting this patient before some of

the dental and medical societies of Philadelphia, and afterward published a full account of the case in the *Dental Cosmos* for March, 1883.

Anomalies of Arrangement.

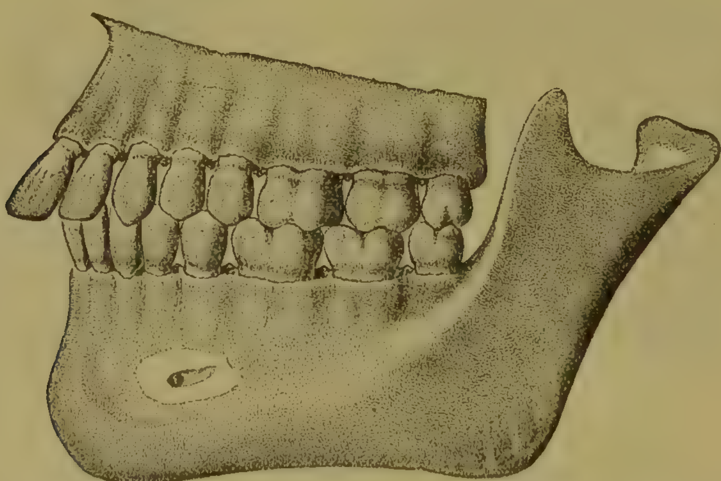
Deviations from the normal manner of arrangement of the teeth may exist either in the form of malformation of the whole or part of the arch or in the malposition of certain teeth in the arch. When the teeth and jaws are so formed and arranged as to admit of normal occlusion, the superior incisors, when the jaws are closed, will lie in close contact with and slightly overlap their fellows in the inferior jaw, while the superior

Fig. 90.



cuspids, bicuspids, and molars, while slightly overlapping those in the inferior jaw, will interdigitate with them. This normal arrangement is well illustrated in Fig. 90. One variation from this condition consists in the protrusion of the superior anterior teeth, giving the individ-

Fig. 91.

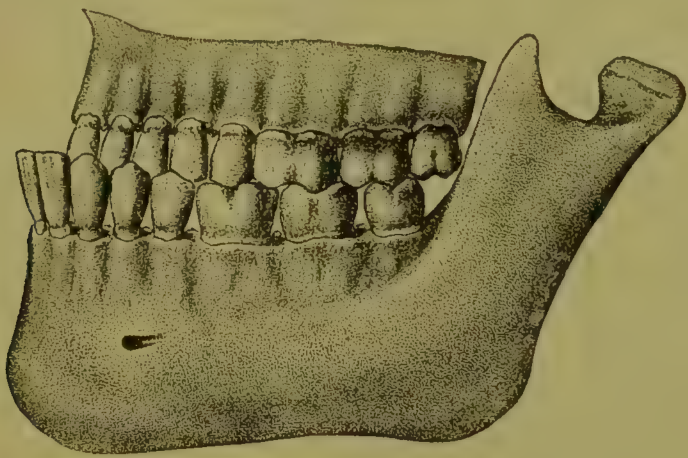


ual an unnatural expression and constituting a marked deformity. In such cases, unless the teeth are unusually broad, spaces will exist between them, and thus, from lack of lateral support and the greater angle at which they are struck by their opponents, they will gradually become

elongated, loosened, and lost. Fig. 91 represents an irregularity of this type.

A condition directly the opposite of this is where the superior teeth are normally and symmetrically arranged, but where the anterior inferior teeth protrude. This form of irregularity, known as *prognathism*, constitutes one of the greatest of facial deformities. The greater prominence given to the lower lip by the protruding teeth, the marked prom-

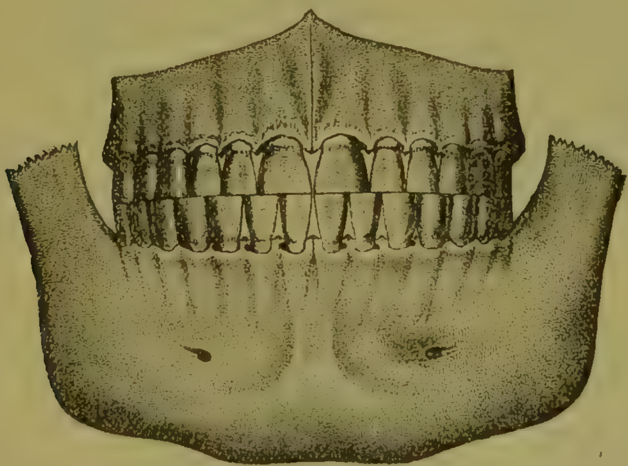
Fig. 92.



inence of the chin, and the change in the angle of the jaw often give to the individual a ferocity of expression decidedly inhuman. (See Fig. 92.)

Between the two latter forms of malformation there exists one in which the teeth of neither jaw overlap, but meet edge to edge. This condition is productive of little if any facial deformity, and is chiefly detrimental to the individual in causing the more rapid abrasion of the

Fig. 93.



cutting edges and masticating surfaces of the teeth, causing them to become painful and hastening their loss. (See Fig. 93.)

Other instances of variation from the normal type in teeth and jaws are where the incisive edges of the anterior teeth in each jaw meet, but both are introverted, giving to the individual the appearance of greater age; or where there is protrusion of both the superior and inferior teeth; or where in the superior jaw there is an abnormal contraction

and consequent narrowing of the arch in the region of the bicuspid or molar teeth.

Another abnormality of the jaws affecting the appearance and usefulness of the teeth is where either through excessive development of the alveolar process in the posterior segments of the jaw, or through an undue lengthening of the molars, the anterior teeth fail to meet. In cases of this character all of the molars antagonize, but the remainder of the teeth are permanently separated, the separation being greatest at the median line and gradually diminishing from there backward.

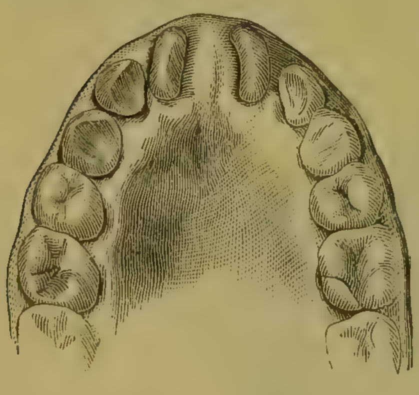
Malposition of Individual Teeth.

Malposition in the deciduous set is of rare occurrence, and when found it generally consists in slight torsion and overlapping of the inferior or superior incisors. Malposition in the permanent set is quite commonly met with, and the causes that may or do produce it are so numerous and well understood as to need but little elaboration.

Superior Centrals.—These teeth are frequently found crowded against each other, with one overlapping the other. When this condition occurs only after they are fully erupted, and while the adjoining teeth are struggling into their respective positions, the deformity may justly be attributed to lateral pressure ; but where it occurs coincidently with their emergence through the gums (as it frequently does), with no signs of the near approach of their neighbors, we are at a loss to account for the condition.

Oftentimes just the opposite condition is found—namely, regularity of position of the teeth, but their separation by a space more or less wide. This peculiarity is most plausibly accounted for by the supposition that the median septum is either abnormally thick or particularly unyielding. Occasionally this condition is accompanied with torsion of the involved teeth, thus producing a more unsightly deformity. (See Fig. 94.) This additional twisting of the centrals may be caused by the septum as mentioned, or by the presence of a deciduous or supernumerary tooth in or near the centre of the arch. Frequently also one or both of the centrals may occupy a position outside or inside of the arch. When inside, they are generally caught and retained in their abnormal position by the occlusion of the inferior teeth. Their eruption inside may be accounted for by the deflection of their cutting edges in the course of eruption or by the abnormal position or lack of absorption of the root-apices of their predecessors.

Fig. 94.



Superior Laterals.—The superior lateral incisors are more frequently malposed than the centrals. Their slight overlapping of the distal margins of the centrals is of such common occurrence that it ceases to impress the practitioner as an abnormality, and has been copied by the makers of artificial teeth in order to give them a more *natural* appear-

ance. Their emergence inside of the arch occurs frequently, and may be caused by delayed eruption, during which time the cuspids have prematurely erupted and appropriated part of their space, or it may have taken place after full eruption from pressure upon them by the erupting cuspids in seeking their places in the arch, where there is too little room to accommodate them.

Inferior Incisors.—Irregularity of position in these teeth has come to be a condition more frequently met with than regularity. Their size, larger than that of their predecessors, and their normal eruption inside of them, will naturally cause them to assume an irregular position, unless the anterior segment of the jaw enlarges sufficiently to accommodate them—a condition frequently lacking. One or more of them may be thrown so far forward by the crowding of their fellows as to cause them to bite outside of their antagonists in the other jaw, although this condition is seldom met with. Their irregularity generally consists in an uneven alignment and a more or less axial torsion. In many cases later enlargement of the alveolar border will enable them to assume a more correct position.

Cuspids.—The cuspids are more frequently malposed than any of the other teeth, excepting, possibly, the inferior incisors. They may take a position either without or within the arch, although the former is by far a more common condition. This is readily accounted for by the fact of their late eruption, when by crowding of the adjoining teeth or by lack of development of the jaw the space left for them is insufficient for their accommodation. Very frequently they are turned or twisted in their sockets at an angle of 90° or less, and in rare instances at an angle of 180°, from their normal position. At times, also, by premature eruption coincident with delayed eruption of the laterals, the cuspids take a position adjoining the centrals, thus either forcing the laterals to occupy a position outside or inside the arch, or compelling their imprisonment within the process. Occasionally the cuspids of the inferior jaw are found to be slightly malposed, but this is rarely the case.

Bicuspids.—The first bicuspids of the superior jaw are seldom found out of their proper position, but the second bicuspid is not unfrequently somewhat misplaced. Especially is this likely to be the case when from any cause its predecessor, the deciduous second molar, has been lost before its time. In that event the permanent first molar is apt to press forward and occupy a portion of the space, thus compelling the bicuspid to seek a position other than normal.

Fig. 95.

Cases have been met with where, from an insufficiency of space between the cuspid and first molar, both the bicuspids, in order to be accommodated, have been obliged to assume a position side by side across the arch. (See Fig. 95.) Even when retaining their alignment in the arch, one or both are often found somewhat turned in their sockets.

The inferior bicuspids are liable to the same forms of irregularity as the superior ones, though with them the condition is both less frequent and less pronounced.

Molars.—Various causes sometimes produce irregularity in the position of these teeth, although in the case of the first and second molars it is rather infrequent. The third molars are most commonly found somewhat out of line, this being no doubt due to the fact that they are the last to erupt and to the lack of space remaining for their accommodation. When malposed the superior third molars are usually everted or turned toward the cheek, while the inferior are mostly antroverted or dipped forward.

Closely allied to the anomalies of arrangement, and yet falling more within the subject of location, should be mentioned two additional types of anomaly—one where fully-developed teeth lie imbedded near to their normal position, but are never erupted, and the other where teeth are similarly imbedded, but at points more or less remote from their proper locality. The former may well be denominated *imprisoned* teeth, and the latter *migrated* teeth.

IMPRISONED TEETH.

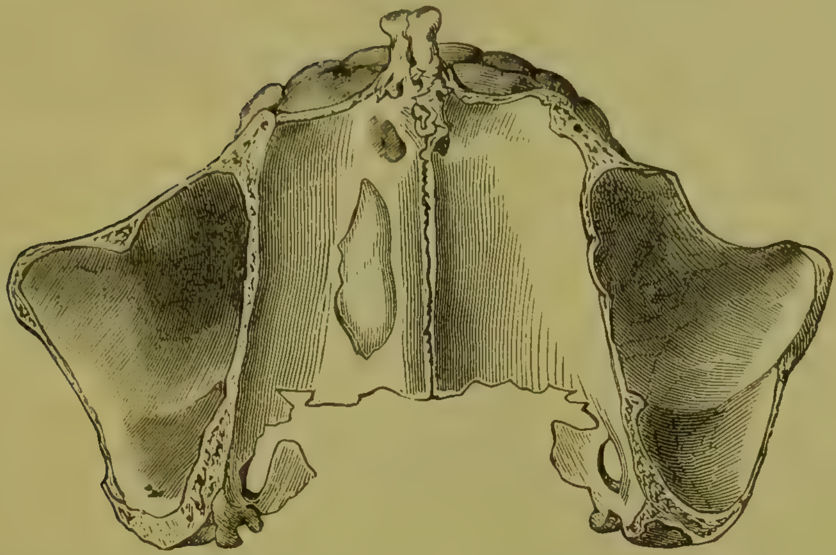
Imprisoned teeth are not infrequently met with, and their existence and location may be determined by the protrusion of the bony plate beneath which they lie, or their existence may be brought to light only after death. Their non-eruption is due to their abnormal position, and this is doubtless to be attributed to some force or impediment which causes the deflection of the crown from its normal direction on its way toward eruption. The continued development of the root at an angle to the crown only serves to lessen the possibility of its ever assuming its position in the arch.

The superior cuspids and laterals and the superior and inferior third molars are the ones most usually found thus imprisoned. The cause for the imprisonment of the superior laterals is not easily found, but that of the other teeth mentioned is unquestionably due, in the majority of cases, to their later eruption and to the frequent partial closure of their allotted space by the approximation of adjoining teeth. Albinus reports a case in which the superior cuspid teeth were situated between the nasal cavity and the orbit on either side, with the crowns directed upward.

FIG. 96.

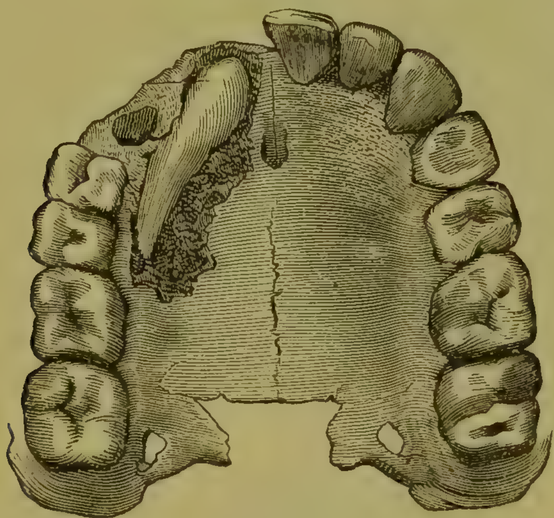
Hunter reported a similar case. Wedl illustrates the case of an imprisoned inferior cuspid lying transversely of the jaw underneath its normal position (Fig. 96). Forget gives an illustration of a cuspid tooth developed and imprisoned in the thick part of the floor of the nasal fossa, with the crown directed backward; also another, somewhat similar, but with the crown directed toward and nearly reaching the central incisor of the opposite side (Figs. 97, 98). The poet Goethe in 1797 observed in an osteological specimen owned by Rapp

FIG. 97.



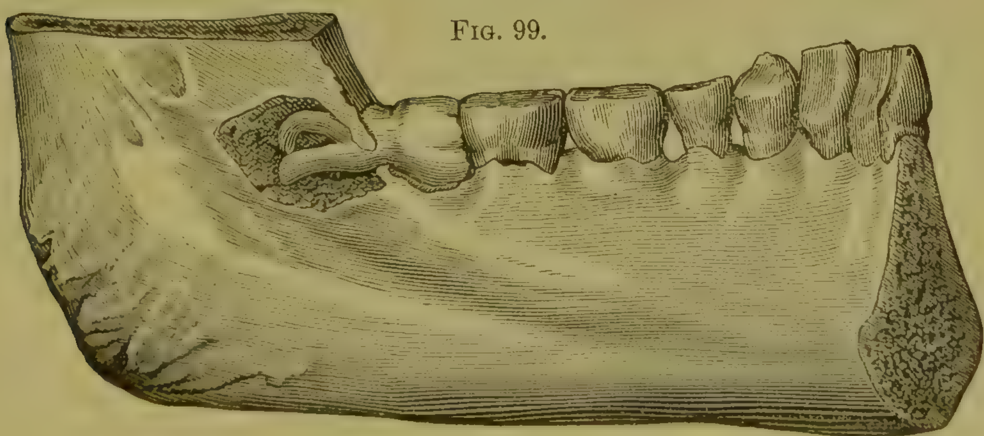
of Stuttgart a bicuspid located in the nasal cavity beneath the margin of the orbit, its roots firmly attached to a small osseous mass.

FIG. 98.



Cases of the imprisonment of the inferior third molars are quite common, and the condition is frequently the cause of severe neuralgic pains

FIG. 99.



and of other disturbances. These teeth may occupy almost any abnormal position, but the one most frequently met with is where they assume a nearly horizontal position, with their masticating surfaces in contact with the distal surfaces of the second molars. Fig. 99 well illustrates this condition.

The existence of imprisoned teeth is sometimes revealed by their partial uncovering in the process of alveolar absorption late in life. When thus exposed they are often erroneously regarded as members of a third set.

Migrated Teeth.

Instances of teeth found far away from the alveolar arch in unusual positions are quite rare, although several such are recorded. When thus found they are generally encysted. Dr. Bolles[1] says the wisdom teeth are most frequently encysted, and next in order of frequency come the cuspids. Dr. Sayre[2] relates a case where three molar teeth were separately ejected through the meatus auditorius externus of a little girl under his care.

Ovarian cysts containing teeth and hair are sometimes met with, and are generally regarded as the result of involution. The most remarkable case of this kind within the writer's knowledge was one presented at the meeting of the American Dental Association, Niagara Falls, Aug., 1886. The specimen shown consisted of an irregular osseous mass enclosing about twelve teeth, part permanent and part deciduous, but all so fully developed and normal in character as to be readily distinguishable, although mingled in much confusion. Attached to some dermoid tissue overlying part of the bony mass was a tress of hair fully an inch in diameter and fifteen or eighteen inches long. Most singularly, this cyst was removed from an unmarried woman about twenty-four years of age and a virgin.

Anomalies of Size.

Anomalies of size are seldom found in entire sets of teeth. According to Nature's harmonious working, large teeth are usually found only in individuals of large frame and stature, while small teeth belong to those of diminutive size. The teeth of giants are generally large, while those of dwarfs are small. When variations as to size occur, they are generally confined to a single tooth or to a pair of teeth.

Excess of Size.—When individual teeth of excessive size exist, they are most generally found as central incisors, cuspids, or molars. Abnormally large centrals almost invariably have short and stunted roots, while the cuspids and molars have roots equally as large in proportion as the crowns. Fig. 100, copied from a cut in Coleman's *Dental Surgery*, represents a pair of abnormally large centrals, while Fig. 101, from Carabelli, illustrates a pair having flattened conical roots.

When cuspids are of abnormal size the excessive development is principally shown in the length of root. Dr. J. D. Thomas has shown

[1] *Med. and Surg. Journal*, 1871. [2] *Amer. Med. Monthly*, 1860.

the writer one that measured one and a half inches from cusp to apex. Of the molars, the one most generally found to be excessively developed is the superior first, although the superior third is sometimes found of excessive size through coalescence with another tooth. Occa-

FIG. 100.

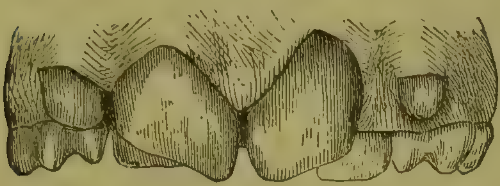
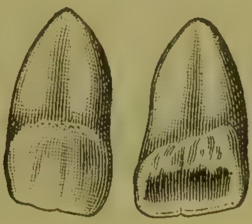


FIG. 101.



sionally the inferior second bicuspid attains an unusual size of crown through the division by fissure of the lingual cusp into two distinct cusps.

Deficiency in Size.—The tooth most frequently found of diminutive size is the superior third molar or wisdom tooth, although occasionally the superior laterals are found considerably smaller than they should be as compared with the adjoining teeth. Dwarf wisdom teeth are so frequently observed that they have almost ceased to be objects of special interest. When present they take the place of the normal teeth and occupy a regular position in the arch directly behind the second molars. In shape they are sometimes simply conical, both as to crown and root, but more frequently, while the root is a single cone, the crown is an exact counterpart of the crown of the normal tooth with its three distinct cusps and central pit or depression. In size they vary from the proportions of a grain of rice to twice or three times that magnitude. Fig. 102 represents a dwarf wisdom tooth, the crown of which is perfectly formed, while the root is a single cone. The transverse diameter of the crown is three-sixteenths of an inch, while the root is but little over a quarter of an inch in length.

FIG. 102.

ANOMALIES OF STRUCTURE.

Variations from normality in the structure of the teeth may pertain either to the crown or root, or to both, and are usually attributable to some cause or causes operating while the organ is in process of formation and before its eruption.

Organic Defects of Crowns.—This variety of anomaly was denominated "atrophy" by the older writers, but the term was not well chosen, from the fact that the defects are faults in formation, and not a wasting or loss of substance after eruption. Its most common expression is that of a series of irregular pits or depressions in the enamel extending transversely across the tooth or entirely around it. Sometimes teeth are marked with two or three rows of these pits. These depressions may be separated one from the other, or they may be confluent and form an irregular horizontal groove. (See Fig. 103.) At times they penetrate but a short distance into the enamel, while in

others they pass entirely through it, their margins presenting a rounded and glossy appearance. Two, four, or six of the anterior teeth in each jaw are generally found to be affected, while the first molars are often similarly involved.

Fig. 103.

That the other molars and bicuspids are not usually affected is due to the fact that at the time of the constitutional disturbance their enamel-caps had not yet begun to calcify. The location of the markings will show that the influence which produced them was operative at between two and four years of age. The diagram of Prof. Peirce, as given on p. 647 of Vol. I. of the present work, showing the ages at which calcification of the permanent crowns takes place, will well illustrate this fact.

Sometimes, instead of rows of pits half the crown is entirely devoid of enamel, while the remaining half next to the gum is normally covered. Fig. 104 shows this condition. As to the cause of this malformation various theories have been put forth. Some thirty years ago, in a series of papers read before the Pathological Society of Great Britain, Mr. Jonathan Hutchinson claimed that this condition of pitted and denuded teeth was due to the administration of mercury in infancy, and for this reason he denominated them "mercurial teeth." Mr. Bridgeman in 1876 advanced the theory that the condition was due to an electro-chemical action on the teeth as they erupted. This latter theory found little favor, while the theory of Mr. Hutchinson found many supporters, and is to-day accepted by many intelligent practitioners and investigators. The abnormality is quite a common one, and the administration of mercury in childhood for various disorders is also quite common, so that where teeth of this character are found it is on inquiry often ascertained that the individual has taken mercury in early life. We do not think, however, that any real relation between the two as cause and effect has been established, for the condition is very frequently met with in countries where the administration of mercury is seldom if ever practised.

Fig. 104.

A more probable explanation of the cause was given by Harris about thirty years ago. He says: "It is always congenital, and most probably results from constitutional disease, whereby the secretion and deposition of earthy salts in the enamel-cells is interrupted, and by occurring at the time this process is going on prevents their being filled up, causing them to wither and perish. Afterward the secretion of earthy matter for the enamel-fibres will be resumed and its deposition take place in a normal manner." A second interruption may take place a little later on, resulting in the formation of a second row of pits nearer the

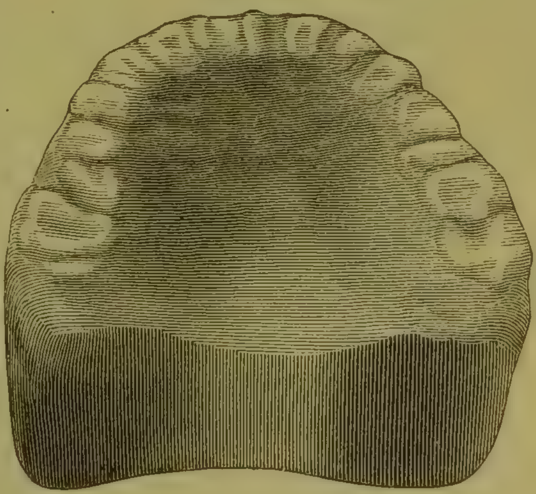
gum. Any of the eruptive fevers may be responsible for the condition, while at the same time convulsions or any violent interruption of the formative process may produce the same result.

A condition varying somewhat from that just considered is where the same teeth on their emergence from the gum show a lack of enamel only on a portion of the cutting edge corresponding to the middle cusp or lobe, and a contraction or lessening of width at the cutting edge by the rounding of the mesial and distal corners. Shortly after eruption the thin dentine of the middle portion is rapidly worn away, leaving a crescentic or semilunar notch in its stead. Fig. 105 represents teeth of this character. Mr. Hutchinson, having noticed in his large hospital experience the coincidence of this condition with inherited syphilis, concluded that the anomaly was the result of the disease, and regarded teeth of this character as partially if not absolutely diagnostic of the existence of the malady. For this reason the notched teeth have ever since been spoken of as "Hutchinson teeth" by many writers. Whether he was correct in his conclusions has never been fully determined, for his views have met with indorsement and opposition by those whose opinions are equally valuable.

FIG. 105.

Another type of defective crown-structure seldom met with is where the roots are fully and normally developed, but where all the crowns are rudimentary in character. In cases of this character the crowns amount to but small irregular masses of dentine entirely lacking the enamel covering. Dr. Barrett of Buffalo a few years ago reported a case of this kind that came under his care. The patient was a young man whose teeth were worn to the gum line. All the pulps were living and the teeth were free from sensitiveness, the pulp-chambers having been filled with dark and hard secondary dentine. The patient declared that the teeth were crownless when erupted, although in all probability there had been rudimentuary crowns which had been worn down. Figs. 106 and 107 represent the appearance of the teeth in each jaw.

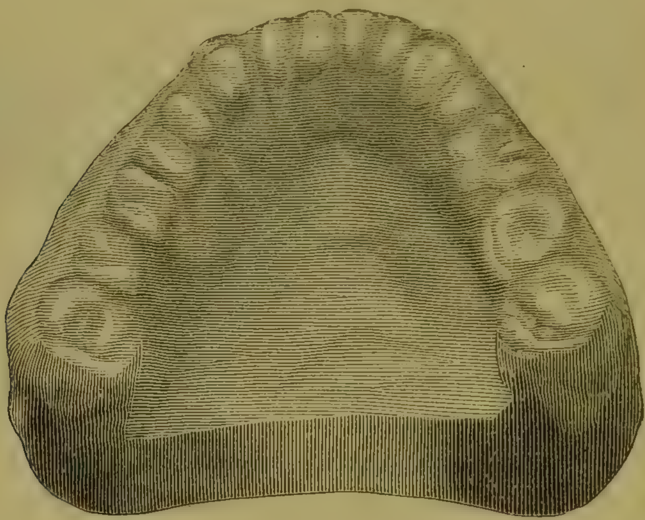
FIG. 106.



Dr. D. B. Freeman of Chicago has kindly furnished the writer with models and description of another very similar case. The patient was a medical student aged about twenty-six years. The enamel was totally lacking on all of his teeth except the second and third molars, and even on these it was deficient and imperfect in places. All of the crowns were very much worn, those anterior to the molars being level with the gum line. They were not then, nor had they ever been, sensitive. He could not rememember when they were in any other con-

dition or in appearance different from that which they then presented. He said that his ancestors for three generations on his father's side had this peculiar deficiency of crown-structure, and his three brothers and two of his sisters presented the same condition. His four other sisters

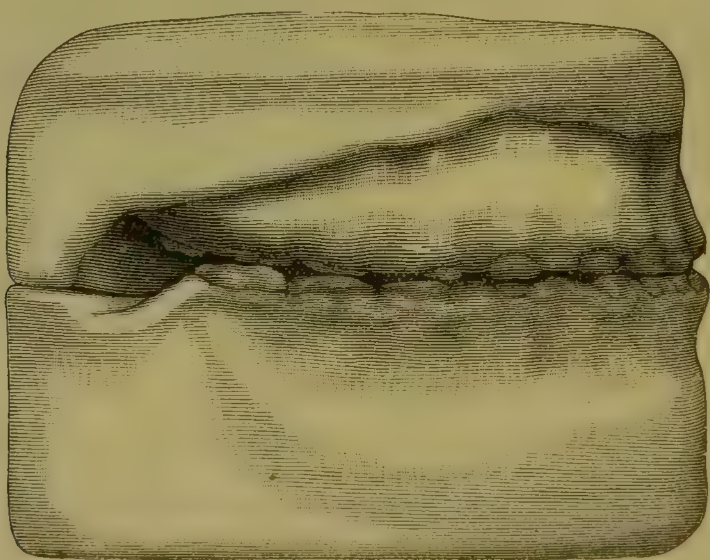
FIG. 107.



had perfectly-developed teeth like his mother's. Fig. 108 shows the worn character of the teeth and their appearance with the jaws closed.

Compressed or Flattened Crowns.—Among the anomalies of tooth-structure or formation this one is quite rare. The crowns of this character are flattened in an antero-posterior direction, so that their

FIG. 108.



diameter transversely of the jaw is by far the greater one. The fissures or sulci, instead of presenting the usual form, are distorted and sigmoid in shape, corresponding with the long diameter, while the cusps resolve themselves into narrow ridges somewhat after the manner of the molars of the Ruminantia. The third molars of the

superior arch are the ones usually thus affected, although the writer has seen one case in which the superior first molar presented the same condition. Fig. 109 is a typical representative of this class of crowns. It is a third molar from the left side above.

Fig. 109.

Flexions of Roots.—Flexions of the roots of teeth are among the more common expressions of anomalous condition. These flexions may pertain to the one root of the single-rooted teeth or to one or more of the roots of the multi-rooted teeth. The curvature may also, in different cases, be found at any point between the neck and the apex. Figs. 110–113 represent this condition in some of its extreme aspects. The roots of very few teeth occupy a vertical position, but most of them exhibit a greater or less curvature or inclination backward, while occasionally, especially in the bicuspid teeth, the curvature is slightly in an anterior direction. Slight curvature, however, is not

Fig. 110.

Fig. 111.

Fig. 112.

Fig. 113.

regarded as anomalous, and it only becomes so when it is excessive. These flexions seem to present every variety of form, from that of a single curve to that of a series of curves and spiral shapes.

The roots most excessively deflected from their normal course are those of the superior and inferior third molars; next to them come the cuspids; then the bicuspids; and lastly the incisors. From this fact it will be noticed that the roots most usually found thus affected belong to teeth that are late in erupting; and this will naturally suggest one of the most frequent causes of their deflection. As the crowns approach the surface of the gum their roots lengthen in the opposite direction by calcification until development is complete. If, then, there be delay in the eruption of the crowns from any other cause, either lack of space or other condition, the roots in their lengthening will soon reach the denser structure of the true maxillary bone, and, being unable to extend themselves farther in that direction, they will naturally take some other course in the softer alveolar tissue.

Flexions of Crowns.—Anomalies of this character are exceedingly rare, and when met with pertain almost exclusively to the incisor teeth of the superior arch. When the flexion occurs at or near the neck of the tooth, as it usually does, it presents the appearance of a reunited fracture; this fact led Mr. J. Tomes to apply to it the term "dilaceration." He described the condition as "dilaceration of partially-developed teeth from the formative pulp," and asserted that after the rupture the formation of dentine was resumed in the abnormal position. He attributed the result to some forcible blow during the early eruptive period. Wedl, on the contrary, ascribes the condition to "continued

pressure of a tooth already cut upon one whose development is interrupted or whose eruption is retarded." He considers it hardly conceivable that external force should suddenly bring about this condition in a young and highly vascular tooth, and yet have the pulp survive and continue its work as before. Fig. 114 perfectly represents this unusual condition. It is a superior right lateral, taken from the mouth of a boy (history not ascertained) on account of the unsightly and uncomfortable position of the crown. On the lingual surface the enamel at the neck is separated from that of the crown by the space of one-sixteenth of an inch, and the gap is filled with dentinal or cemental tissue. On the labial surface there is a similar break in the continuity of the enamel, and by reason of the bending of the crown the enamel at the neck overlaps that of the crown for quite a distance, although each portion of the same remains separate and distinct. This would lead us to believe that either there was a rupture of the enamel-cap or organ on the lingual surface before calcification had taken place, and the latter process had gone on without interruption, or that the enamel was calcified before the rupture took place; which seems highly improbable. On the labial surface, where enamel overlies enamel, there must have been a folding of the enamel-organ, the under portion of which continued to calcify in spite of the pressure from above. Had the enamel-cap been torn from the underlying portion, dentine would have come in contact with dentine and coalition been the result.

FIG. 114.

The union of two teeth, while of rather rare occurrence, is represented by specimens in almost every dental collection, both public and private. This union may occur during the development of the teeth or after that process is complete. If occurring during development, it is termed (for want of a better word) *fusion;* when it occurs later, it is known as *concrescence.*

In fusion there is a union of two adjacent germs, which, instead of developing separately, as is the case normally, for some reason become united, and their subsequent development proceeds in a joint manner. The blending of the two teeth is so complete that they have a pulp-chamber in common, and the hard tissues of the one pass evenly and imperceptibly into the other, the only real evidences of the fusion being the abnormal size of the crown, the number of roots, and the groove on the surface of crown and root indicating the line limiting their individuality. The complete union of the soft and hard tissues indicates that it must have taken place while they were in the saccular stage of development. If it had occurred after calcification had begun, the line of union would necessarily be well defined in the internal structure; which is not the case. "The possibility that two separate crowns might be blended together by a resorption of the proximal surfaces, or that two perfectly-formed and separate roots, each with its canal, might be united into one root with a common canal, is quite inconceivable."[1]

Fusion is *complete* when both crowns and roots are united, and *partial* when the union is confined to the roots or the crowns. In complete

[1] Wedl, p. 151.

union both teeth necessarily are side by side and occupy the same position, whereas in partial union they may be parallel or one may stand at a greater or less angle to the other. The condition is met with about as frequently in the deciduous as in the permanent set. In the deciduous set it is almost exclusively confined to the incisors and cuspids of either jaw, and pertains more frequently to the upper. Of the permanent teeth the superior incisors and the wisdom teeth of either jaw are the ones most generally involved.

Figs. 115 and 116 represent two cases of complete triple fusion of the deciduous teeth in the possession of Dr. Douglass of Romeo, Michigan. Fig. 115 shows the deciduous right superior lateral incisor and cuspid, with a supernumerary tooth between the two, taken from the mouth of a three-year-old child. Fig. 116 is a cut of a case very similar to that of Fig. 115. The same teeth are involved, but the specimen is marred by the absence of the central portion of the crowns, the result of decay. Such cases of triple union are exceedingly rare.

FIG. 115.

FIG. 116.

Fig. 117 illustrates a case of complete fusion of the permanent right superior second and third molars, taken from the mouth of a lady. There is perfect union of both crowns and roots, although the individuality of each is maintained throughout. The specimen shows four separate roots and three others perfectly fused together.

FIG. 117.

Heider mentions nineteen specimens of fused or blended teeth in his collection, eight of them belonging to the deciduous and eleven to the permanent set. The latter include three cases of fusion of the superior left central and lateral, and one of the inferior right central and lateral; two cases, upon the right and left sides respectively, in which the superior second molar is blended with the wisdom tooth; and one instance, similar to the latter, where the inferior second molar and wisdom tooth are united; in one case a lower right wisdom tooth is blended with a supernumerary wisdom tooth; and, finally, one presents a fusion between a lower wisdom and a so-called conical supernumerary tooth. The blended deciduous teeth are limited chiefly to those of the upper jaw; in three of the cases the central is united with the lateral incisor; in four of them the laterals are blended with the cuspids; and, finally, in one case a lower cuspid is united with the first molar.

Fusion of the roots of adjacent teeth is seldom encountered, and can, of course, only occur during the development of the roots. In cases where it seems to have occurred after the roots have been fully formed it will be found on examination that these roots are not really fused, but only united by cementum.

Fusion of the crowns of teeth, the roots remaining separate, are more frequently met with, especially in the region of the wisdom teeth. The crowns of these teeth are often found fused with those of the adjoining second molars, and occasionally with the crown of a supernumerary tooth. From the lack of outward sign of union of the crowns, they

are frequently erroneously regarded as a single crown abnormally developed, with a multiplicity of roots. The most perfect specimen of this kind the writer has met with is one in the possession of Dr. Kimmell, illustrated in cut. It was extracted from the mouth of a gentleman twenty-five years of age, and occupied the place of the left superior second molar. It is probably a fusion of that tooth with the third molar. Fig. 118 is a mesio-buccal view; Fig. 119, mesio-palatine; while Fig. 120 is a vertical view of the crown. The length of the disto-buccal root with its portion of the crown is eight-tenths of an inch, while the circumference at the cervix is one and six-tenths of an inch.

FIG. 118.

FIG. 119.

FIG. 120.

Concrescence.—Concrescence, or growing together after complete development, can of course only pertain to the roots of teeth. These become coherent through hypertrophy of the cementum of adjoining roots—a process of quite common occurrence. When this excessive development of the cementum takes place, the root or roots gradually enlarge; the adjoining alveolar septa are absorbed under the influence of pressure; resorption of the pericementum follows, and the cementum of the two or more roots becomes coalesced.

As the enamel is a structure of such slight vascularity, and as there is never a new development of it, coalescence of the crowns is an impossibility. Concrescence of the roots of the same tooth is a very common occurrence, and may involve a portion or the entire length of the roots. Figs. 121 and 122 illustrate this condition in the case of two superior molars. The roots most commonly found thus affected are those of the molar teeth in each jaw, especially the third molars. The limited space for the accommodation of these teeth brings their roots into closer proximity and makes their union easier of accomplishment.

FIG. 121.

FIG. 122.

Concrescence of the roots of adjoining teeth is not so frequently met with, though there are many instances of it. It usually occurs between the roots of the superior second and third molars, though it is occasionally met with in other teeth. The union is most generally confined to the extremities of the roots, although their entire length may be involved. Should it occur before one of the teeth has assumed its normal place in the arch, the further eruption of that tooth will be prevented. If either one should have to be extracted, both teeth will probably come away together. Fig. 123 represents a case in which a second and third superior molar, coalesced near the extremities of two of their roots, were removed together in the attempt to extract one of them.

Occasionally, one and very rarely two supernumerary teeth are found coalesced with one of the molar teeth, usually in the superior arch. Fig.

124 represents a left superior molar from the writer's collection in which two perfectly formed supernumerary teeth or odontomes are attached throughout their entire length to the root and crown of the molar. The molar alone is enormous in size, though perfect in form, and was removed from the jaw of a negro.

Fig. 123.

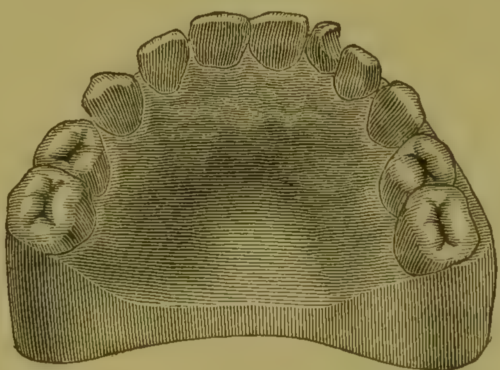
Fig. 124.

Geminous or Connate Teeth.—Gemination or twin formation results from the occurrence of a double dental germ in a single sac, from which are developed two teeth of the same kind where normally there should be but one. The two teeth may be of equal size and similar form, or one may be fully formed while the other is stunted in its development. The two likewise may be more or less united or entirely separate.

The anomaly is of very rare occurrence, although the condition is often confounded with fusion. They differ in this, that in gemination we have two developments from a double germ in a single sac, while in fusion we have two developments from a coalition of two sacs with their respective germs. In the one case there are two teeth of the same kind instead of one, whereas in the other there are two teeth of different character. Wedl says that he has never seen the condition except in the wisdom teeth, but the writer has seen it several times in connection with the anterior teeth. Fig. 125 represents a twin formation of two superior permanent laterals, and Fig. 126 another of deciduous superior laterals. Both are specimens from the museum of the Philadelphia Dental College.

Fig. 125.

Fig. 126.



Multiplicity of Roots.—Teeth having a greater number of roots than properly belongs to them are frequently met with. Such teeth have their roots increased in number, either through the addition of supplemental or adventitious roots, by a division of one or more of the normal roots, or by the fusion of the crowns of two teeth while their roots remain separate.

Supplemental roots may have the same length as the normal roots, but most generally they are shorter. They may be found attached to the necks of the teeth or to some point in their length. Figs. 127 and

Fig. 127.

Fig. 128.

128 show a superior and inferior incisor respectively with these cervical offshoots. The supplemental root, which is almost always round in sectional outline, and contains, of course, its own pulp-canal with branch of pulp, is more frequently met with in connection with the inferior molars than with any other teeth. On these teeth it has its base or commencement at the cervical border on the lingual surface between the two normal roots, and frequently attains to the full length of the other roots. Increase of number through division is far more common than by supplement. While it does not and could not well occur with round roots, it is quite a common occurrence with the flat roots of the multi-rooted teeth and the single flat-rooted teeth. Thus it is frequently met with in the inferior incisors and cuspids, the superior bicuspids, and the molars of either jaw. Fig. 129 represents an inferior cuspid with bifurcated root, the bifurcation extending almost to the neck. Bifurcation of the root of the superior incisors and cuspids and the inferior bicuspids is very rarely met with, their roots being round. In the superior first bicuspid instead of the bifurcated root we sometimes find three distinct and well-developed roots. It will be noticed in such cases that two of the three roots (as in the molars of the same jaw) are on the buccal side, and that they are in reality a result of the division of the normal buccal root, and not an increase by addition, as is often supposed. In the superior molars five distinct roots are not uncommonly met with, and here, again, a careful examination will reveal the fact that two of them owe their individuality to the division of the two buccal roots. In like manner, either one or both roots of the inferior molars may be divided, giving us respectively three or four roots. Instances of this are not uncommon. Often when there are five, and always when there are more than that number of roots attached to the crown of an upper or lower molar, it may properly be considered a case of fusion of two crowns.

Fig. 129.

Deficiency of Roots.—As in certain cases we have the normal number of roots augmented by division or supplement, so, on the other hand, we may have the normal number lessened by blending. This blending may be actual, resulting in the coalescence of certain roots while in their developmental stage, including the conversion of two or more of the pulp-canals into one, or it may only be apparent, and represent the concrescence of the roots by cemental increase, while the roots maintain their individuality internally. When this latter condition exists, the number of roots contained in the mass may sometimes be determined by shallow longitudinal grooves marking the lines of union, or these may be entirely lacking and the mass present an even and unbroken surface. Fig. 130 illustrates a superior molar in which the roots are thus evenly united.

Fig. 130.

Blended roots are more commonly found in the wisdom teeth than any others; and this is in part due to the limited accommodation for

these roots and the resultant pressure tending to bring them into very close proximity. In the superior third molars the roots are sometimes perfectly blended almost to the end, but there they stand out individually in different directions, somewhat in the form of a tripod.

Enamel-Nodules.—Another peculiarity of structure possessing interest, though of rare occurrence, is the formation of so-called enamel-nodules at or near the necks of teeth. They are found attached to the roots at their base or some point near by, and occur most frequently on the superior molars. At times they are situated on the under part of the crown between the roots, but most usually they are placed on the buccal side near the neck. They are spherical in shape and firmly attached to the cementum, being always separated from the enamel of the crown by some little space. While generally known as enamel-nodules, a section will show that they are in reality nodules of dentine perfectly covered by a solid envelope of enamel. They are peculiar on account of their size and shape, but more especially from the fact that the enamel with which they are covered usually has no connection with the enamel covering the crown. The cause or manner of their formation has never been explained, but it seems probable that the enamel with which they are covered has been developed from a portion of the crown-enamel membrane which became severed from the main portion during tooth-formation. The writer has never seen more than one on a single tooth. Fig. 131 illustrates their appearance and most common location on a superior molar.

FIG. 131.

Supernumerary Cusps.—Dentiform excrescences or additional cusps are often met with in certain teeth. They vary in size from the merest projection to the full-sized cusp, and are almost always found on the lingual surfaces of teeth. Though at times they are met with on any of the molars, their most common situation is on the superior first molars. They are usually located below the mesio-palatine cusp, about midway between it and the gum. On the superior incisors and cuspids they are not unfrequently met with in a very rudimentary form, and are situated on the lingual surface near the neck. The sharp angle formed by their sides with the normal surface of the tooth affords a lodgment for débris which is apt to result in caries very early in life.

Advanced and Retarded Eruption.

Variations in the time of eruption of the deciduous and permanent teeth are occasionally so wide of normality as to possess considerable interest. Premature dentition attracted attention in the earliest times, and had connected with it certain superstitious beliefs in regard to the future welfare of the individual. Pliny the Younger has handed down to us several instances of prenatal dentition, the most conspicuous of which was that of the Roman consul Marcus Curius, who on account of having been born with a full set of teeth was surnamed Dentatus. Zoroaster, the Persian legislator, is also said to have had a complete set of teeth at birth. Louis XIV. of France and his secretary of state, Cardinal Mazarin, were each born with two teeth. Richard III. of

England and Mirabeau are both said to have had congenital teeth. Haller collected a list of nineteen cases of teeth at birth, and very many more have been recorded since by others. John Tomes refers to a well-authenticated case of full dentition at birth occurring in a still-born negro child in North Carolina. The writer has two nieces, both of whom were born with two inferior centrals through the gum.

Quite a difference of opinion exists as to the character of these teeth. In a number of the cases recorded the congenital teeth are described as being malformed, without roots, and having only a ligamentous attachment to the gum, in consequence of which they were soon lost. In other cases record is made of the teeth being normal in character, solidly implanted, and retained until supplanted by their permanent successors. The truth probably is that these premature teeth are of two kinds—the one, supernumerary in character, only partially or imperfectly developed, and consequently soon lost, and having no connection with or influence upon subsequent dentition; the others are normal teeth of the deciduous set, erupted long before their time, and retained as long as their associates.

The writer has in his practice a young man of twenty who was born with a supernumerary tooth, which remained firm in its place until its extraction at ten years of age. It had erupted in the roof of the mouth, on the median line about half an inch back from the centre of the ridge.

Instances of retarded eruption of the deciduous teeth are very rare. Cases in which they never appeared, and instances also of the retarded eruption of imprisoned permanent teeth, are given elsewhere in the present article. Smellie reports a case where the first tooth in the mouth of a patient appeared at twenty-two years of age. Another case is on record of a girl cutting four temporary teeth when thirteen years old, and still another where the deciduous set only made its appearance at six years of age.

Deciduous teeth are frequently retained long beyond their normal period, either by being held in position through close approximation of the adjoining permanent ones or by the failure of the permanent successors to make their way toward the surface. The deciduous second molar, particularly of the lower jaw, is often thus retained. The writer has a patient sixty years of age who still retains one of her deciduous superior cuspids, while one of her daughters, aged twenty-five, has several of her deciduous teeth remaining. Prof. Litch reports a case in his practice where in a patient thirty-five years of age the left superior cuspid is just appearing through the gum; also, another case of a young lady of eighteen who still retains her deciduous molars, and whose permanent cuspids have not made their appearance.

One other condition remains to be noticed, which, while it does not properly come under the head of Anomalies, may be as appropriately treated of here as elsewhere.

Fractured Teeth.

The teeth, owing to their position, are frequently subjected to mechanical violence through a fall, a blow, or by the jaws being driven forci-

bly together. The result of such accident often is the fracture of the tooth at some point of the crown or root. The fracture may be longitudinal, transverse, or oblique, and may result in only slight or in serious injury according to its character and position. When confined to the crown we may have a simple chipping off of a small portion of the enamel, or a larger portion of both enamel and dentine may be removed, or the entire crown may be severed from the root by a transverse fracture. In the first instance the injury is but trifling, and may be remedied or modified by dressing to smoothness with a file or corundum point. In the second case the pulp may become so nearly exposed as to result in serious complications. As it is advisable to preserve the vitality of the pulp even in cases of this character, we may protect the exposed portion by placing in contact with it some non-conducting and non-irritating substance, like gutta-percha, retaining it there for a considerable time by a metallic cap or other suitable covering, in the hope that Nature, thus aided, will through a new formation of dentine next to the exposed portion permanently defend the delicate organ from future thermal or mechanical irritation. The application of escharotics and medicaments to reduce the sensitiveness is most apt to produce irritation which may result in devitalization. Rest and protection have proved more efficacious in bringing about the desired result. Later, if the loss be sufficient to amount to a deformity, restoration may be made with gold or other filling material. Should the pulp not be protected by a new formation, or should it fail to become comfortable, it will have to be devitalized. In that case the injury may be mechanically remedied by the attachment of a porcelain tip anchored in the pulp-chamber and canal by means of a metallic pin or dowel.

Where the tooth has been fractured transversely at the neck or any portion of the crown involving the pulp, the broken portion will have to be removed, the pulp devitalized, and an artificial crown dowelled to the root, unless the removal of the root should seem to be the best course to pursue. The writer had a case in practice in which a boy's superior central incisor had been injured by a fall upon the blade of a skate on the foot of another boy. In this case the entire labial surface of the tooth from cutting edge to neck was scaled off and the pulp exposed. The pulp was devitalized by an arsenical application, the balance of the crown removed, and a porcelain crown mounted on the healthy root.

Where the fracture occurs and is confined to that portion of the root contained within the alveolar walls, the only hope for the preservation of the organ lies in the possibility of a reunion of the fractured portions. Whether or not this can and does take place under favorable conditions has been and still is a disputed question. The reunion of the fractured shaft of a bone is an occurrence that can regularly be depended on with conditions favoring; so too cases of reunion of the fractured tusks of hippopotami have been met with. Reasoning from analogy, it would seem possible that fractured roots of human teeth might also reunite where the pulp has not been seriously injured. The pulp under slight irritation will often be stimulated to the formation of

new dentine, and the pericementum under like conditions will not unfrequently take on new formative action. Two conditions, however, would have to prevail in order to admit of union—one, that the broken portions be held immovably in position during the process; and the other, that the pulp be not seriously affected by the blow or accident causing the injury. The pulp, being an exceedingly sensitive and delicate organ, is frequently and easily devitalized through apparently trivial causes. This being the case, it would seem hardly possible that it would survive a shock sufficient to cause fracture in the dense tissues which surround it. Even should it survive, it would still be necessary, in order to ensure reunion, that the fractured portions be firmly held in position during the reparative process—a condition very difficult to meet.

With, however, all these objections to the probability of reunion occurring, and notwithstanding the further fact that so many thousands of teeth are annually extracted without any evidence of fracture and reunion, cases have been met with and are recorded by those so high in authority as to compel our belief in its possibility. Tomes mentions one or two cases that came under his observation. Wedl refers to two cases, illustrated in his *Atlas*—one of a reunited upper human bicuspid, and the other of an incisor of an antelope. Hohl took pains to form a record of all the reported cases in animals and man up to his time, and in a total of fourteen, eight were human; of these, seven were incisors and one an upper bicuspid. Hyrtl mentions a specimen of reunited fracture of a central contained in the Breslau Anatomical Museum, while Heider had in his collection a specimen of a perfectly united fracture of an upper bicuspid. Probably the most remarkable and best authenticated case of reunion is recorded by Hohl. He says: "Prof. Y——, as he was about entering a railway-car in 1866, fell, striking his mouth upon the sharp edge of an iron step in such a way that the right superior central incisor was broken lengthwise. The fracture separated the tooth in the middle of the crown so completely that the two fragments diverged from each other and could be moved back and forth. After the lapse of fourteen days, during which time the intense pain entirely prevented the use of the fractured tooth, a more comfortable condition ensued, and in a few weeks more the tooth completely resumed its normal functions. The two halves of the tooth became firmly adherent to one another, and the line of union was indicated by merely a fine line with a slightly brownish tinge."

So-called cases of reunited fracture unattended with any history, and where the condition is discovered only in extracted teeth, prove little, if indeed they prove anything at all, for the reason that many anomalies of growth may be mistaken for this condition. Where, however, the history of the case from first to last is well authenticated, as in that just referred to, it proves beyond a doubt that reunion may and does occasionally occur.

HYPERCEMENTOSIS.

By S. H. GUILFORD, A. M., D. D. S.

THIS abnormality consists in an excessive development of the cemental tissue of the roots of teeth. The condition has been treated of by various authors under the titles of exostosis, dental exostosis, hyperostosis, excementosis, dental osteoma, etc., but in the writer's opinion the term hypercementosis (from υπερ, above or excess of, and *cementum*) defines the condition more exactly than any of the others.

While the condition cannot be called a common one, it is too frequently met with to be considered rare. None of the roots of any of the teeth can claim immunity from it under all circumstances, but those of the molars and bicuspids are found to be more frequently involved than those of the anterior teeth. So, also, the teeth of the superior arch are found to be far more liable to it than those of the inferior.

It is found at any or all points of the surface of the root, and varies in size and quantity from the smallest nodule to a complete investment of the entire root or of several roots either of the same or adjoining teeth.

The varieties of form and extent which this hypertrophy assumes may be classified, in a general way, under the headings *circumscribed* and *diffused*.

Circumscribed hypercementosis may be said to include those cases where the enlargement is confined to a limited area, usually small in

FIG. 132.

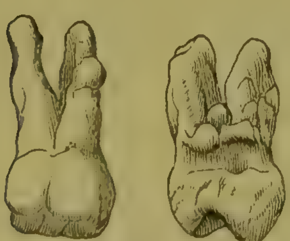
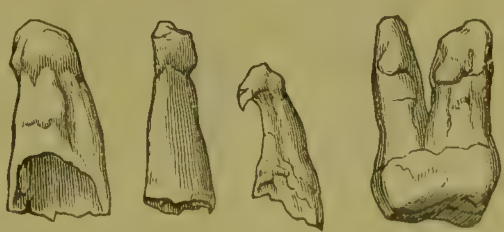


FIG. 133.



extent. It may be nodular in form, appearing as rounded masses either at the apex or on the sides of the root, or it may assume the form of a hooded or dome-like covering of the end of the root. (Figs. 132 and 133[1] respectively represent these forms.) The nodular form is found upon the roots of both bicuspids and molars, more frequently the for-

[1] From Prof. Flagg's article in *Cosmos*, vol. xx., No. 2.

mer, and, aside from any local disturbance which its presence might give rise to, it offers one of the most serious obstacles to the removal of the root when this becomes necessary.

The *diffused* variety includes all cases where the hyperplastic condition involves a considerable territory of root-surface. It may involve but a half or more of the length of the root, or the entire root from apex to neck may be included. It may be greatest in extent at the apex or midway of the length, and in very rare cases is found largest at the neck. (Figs. 134, 135, and 136 illustrate the three points of enlargement.) As previously remarked, this diffusion may be so great as to include all the roots and combine them into one solid mass. Thus combined, their general outline may be almost cylindrical or represent a truncated cone with the base at the neck or the apex according as the roots have been divergent or convergent. Its surface may also be furrowed by more or less shallow vertical grooves indicating the outline of the roots, or it may be so smooth and even as to give no suggestion of their previous isolation. Sometimes the enlargement is of such a character as to occupy far more space in the alveolar process than did the contained roots previous to its formation, and occasionally, too, the longest diameter of the mass will correspond to the shorter diameter of the crown, making it very difficult of removal. (Fig. 137 represents a wisdom tooth in this condition.)

FIG. 134.

FIG. 135.

FIG. 136.

FIG. 137.

Structural Character.—The structural character of cementum is so nearly identical with that of bone that the differences are those of degree and not of kinds of tissue. Each has its calcified matrix or basis-substance, containing canaliculi, medullary canals, lacunæ (cement-corpuscles), etc. Cementum is about as dense as the cortical substance of bone, the manner of formation of both being identical. Hyperplastic cement does not differ essentially in character from the primary cementum, the line of union between the two being in most cases very difficult of demonstration. In normal cementum, as well as in that of a superimposed character, the physical characteristics vary somewhat with the quantity or thickness of the deposit. Tomes says:[1] "When it is limited to a thin layer the lacunæ are altogether absent, and even canaliculi do not appear until a certain thickness is attained. In a longitudinal section of a front tooth the cementum near the neck will present a thin layer of transparent tissue, marked with faint indications of granularity, accompanied in some cases with an obscure linear appearance, suggestive of the idea that the calcification of parallel fibres had contributed to its production. Proceeding in the direction of the root, the cement thickens, and is traversed here and there by canaliculi; and still farther down lacunæ make their appearance, first as a single series,

[1] *Dental Surgery*, p. 423.

then, with an increased thickness of the cementum, in numbers; the number generally depending upon the thickness of the tissue."

Manner of Formation.—Secondary or hyperplastic cementum, like the normal cementum formed earlier, is the product of the peridental membrane or pericementum. This membrane comprises that tissue which intervenes between the root of the tooth and the bony walls of its alveolus, and is the agent by which both these hard tissues are produced. That portion of it lying next to the alveolus produces bone, while the opposite margin, next to the root, is directly instrumental in the upbuilding of the cementum. The fact that the same tissue is capable of producing two hard tissues in most respects similar, and yet dissimilar enough to prevent their union, has led many to infer that the peridental membrane is in reality two membranes lying in close proximity and measurably connected, yet differing one from the other in certain functional peculiarities. Later investigation, however (notably that of Prof. Black), goes to show that the membrane is single, and so constituted as to be able to produce either bone or cementum according to location and required needs.

Both surfaces of this membrane are covered with specialized cells, which are the immediate instruments in the formation of bony tissue. Those on one surface which are to produce bone are termed osteoblasts, while those next to the tooth are known as cementoblasts. When either hard tissue is to be formed these special cells become active in throwing out calcareous salts, which shortly surround them with spherules of lime. These spherules, lying in close proximity, become coalesced and gradually filled up by further calcareous elimination, so as to form a layer of osseous tissue. Another row of cells similar to the first is then produced on the surface of the membrane, which in turn become converted into an osseous layer overlying the first. In this way, layer by layer, the hard tissue is produced until the normal limit is reached.

In the formation of the primary cementum the first layer is attached to the peripheral surface of the dentine. On this the second layer is formed, and so on until the normal quantity is formed, after which the pericementum becomes functionally inactive, and so remains unless again called into use through pathological influences.

In the production of hyperplastic cement the peridental membrane resumes its formative activity, and new tissue similar to the first is added to that already formed. This action may be localized or general according to the conditions operative in bringing it about. In the one case the new growth is circumscribed, and in the other diffused. In either case it may assume considerable proportions, in many instances resulting in a coalescence of the different roots of the molar teeth, and sometimes in uniting the roots of adjacent teeth. When this takes place one or more of the roots is increased in size by the hyperplastic growth, the pericementum is distended, the adjoining alveolar septum is absorbed, and finally, through compression, the membrane itself is dissolved and the roots united.[1]

[1] Dr. Black, in the *Dental Review* for April, 1887, calls attention to the occasional occurrence in the peridental membrane of hard formations closely resembling, but larger than, the calco-spherites sometimes found in the dental pulp, these formations

One of the most remarkable characteristics of this peridental membrane is the power it possesses of being the agent of either the upbuilding or resorption of the adjacent bony tissue. At times it assumes the one function, at other times the other. In many cases the normal cementum has been resorbed at certain points, and this resorption has again been followed by new cemental formation in the same place.

This resorption of bone or cementum is directly brought about by special cells on the surface of the pericementum, known as osteoclasts. These appear to excrete a liquid capable of dissolving away the hard tissue. Whether these cells are the original cementoblasts pathologically modified, or are an entirely new formation, has not yet been definitely determined.

Inducing Causes.—All writers seem to agree in the belief that hypertrophy of the cementum is in all cases induced by irritation of the pericementum, but as to the various agencies operative in its production opinion is still divided. Fox, Bell, and the earlier writers believed that caries in some form was responsible for the irritation. Tomes believes the hypertrophy to be "caused by that condition of the periosteum which is called irritation—a state usually induced by pre-existing disease in other dental tissues, and in a great majority of cases by caries." In addition to caries as a cause, Prof. Flagg[1] mentions "mal-occlusion of teeth; protrusion of fillings at or under the gum margin; slow deposition of tartar; large metallic fillings in proximity to pulp; and alveolar abscess." Prof. Abbott,[2] among other causes, mentions "localized irritation of constitutional origin, such as from gout and syphilis," and "gravitation operating upon an upper tooth after the loss of its antagonist."

While caries is doubtless one of the prime factors in the production of this condition, it certainly is not the only one, nor does it always produce this result. Every dental museum contains specimens in abundance to show that teeth entirely free from caries are often found with hypertrophied roots, while thousands of teeth are yearly extracted in a badly-decayed condition without any indication of root-enlargement. Mal-occlusion by its abnormality and unavoidable irritation is no doubt a most potent factor in inducing this condition, while the irritation of the soft tissues at the neck by the protrusion of fillings may often result in extracemental growth. So, too, the gradual deposition of salivary calculus around the necks of teeth, and its encroachment upon the root, has, by its continuous and persistent irritation, doubtless been as frequent a cause of hypertrophic growth as any other.

As to the influence of alveolar abscess in the inducement of the condition, opinion is divided. Dr. Barrett[3] says: "In the case of roots that have long been in an abscessed condition it will be found that where the pericementum has been destroyed there will be no hypertro-

in some instances being large enough to be seen with the naked eye. Dr. Black states that upon some of the larger specimens he has seen cementum built and "fibre attached, showing that they may become the nidus of an irregular or nodulated hypertrophy."

[1] *Cosmos*, vol. xx. p. 75.
[2] *Cosmos*, vol. xxviii. p. 665.
[3] *Independent Practitioner*, vol. vii. p. 412.

phy, but upon those parts of the root which still retain their attachment a considerable growth will not unfrequently be seen." He also says: "The abnormal deposition of cementum is not dependent upon the vitality of the tooth-pulp. In fact, it seems most excessive in teeth that have long been devitalized." Prof. Abbott,[1] on the contrary, states that "only an irritation of the pericementum while the pulp is living can, in my judgment, result in an increased cementum."

The intimate relation known to exist between the pulp and the pericemental membrane will readily suggest the probability of irritation of the one leading to the same condition in the other, and resulting in increased cemental growth; but the same intimate relation would also lead us to believe that the devitalization of the one would result in such lessening of vital force in the other as to interfere with its resumption of formative activity. Tomes,[2] however, after speaking of the new osseous tissue developed in bone just beyond the line of necrosis, says: "In a tooth the periosteal investment of which has become inflamed, conditions in many respects similar to those which take place in bone may be observed. Thus, the end of the root will be denuded of periosteum, and in some cases diminished in bulk by absorption; higher up the membrane will be adherent and thickened, and beneath this the cementum will be increased by recent additions of new tissue."

When hypertrophy of the cementum is found in connection with teeth that have long been devitalized or are partially invested with an abscess-sac, we do not know that these conditions in any way influenced the increase of tissue. So, too, the fact that teeth that have long been unantagonized are upon extraction found to be largely exostosed does not prove that their abnormality is due either to lack of antagonism or to gravitation, for they may have been hypertrophied before the latter conditions existed.

Another probable cause of hypercementosis is excess of function. Teeth that have survived some of their neighbors, and which have in consequence been required to perform the labor that formerly devolved upon others, will in most cases be found to be affected with hypercementosis. The last teeth remaining before extraction for a full denture will usually be found to be thus affected. In these cases the pericementum has been irritated and stimulated, not indirectly through the pulp, but directly by mechanical impact excessive in character. Among the many specimens of this latter class seen by the writer, *facets* caused by the wear of occlusion or other evidences of excessive use were present.

Prof. Abbott believes that a diffused enlargement of the cementum as a result of pericementitis cannot occur after the cementum has once been fully formed, and regards this character of hyperostosis (diffused) as in most instances the result of fœtal malformation.

Observers have recorded the fact that hypercementosis is never met with in the deciduous teeth, nor in the permanent teeth earlier than the age at which calcification of all the dental tissues is complete, about the sixteenth or eighteenth year. If, then, it is to occur, it must be after the cementum is fully formed.

Bödecker has shown that circumscribed hypercementosis may result

[1] *Loc. cit.*

[2] *Dental Surgery*, p. 438.

from chronic irritation of the pericementum after the completion of tooth-development; and if that of a circumscribed character may be thus developed, it would seem difficult of demonstration that that of a diffused character could not in like manner also be thus capable of formation.

Pathological Results.—The pathological conditions owing their origin to or showing their connection with this abnormal cemental development make the study of it of exceeding importance to the dental practitioner. The development of the cementum, like that of the other hard tissues of the tooth, when confined to its proper limit is normal and physiological, but when the growth of this tissue, either in the beginning or afterward, assumes unnatural proportions, the excessive growth constitutes a pathological condition or abnormality. Being outside of the limit of normality, and occupying space not intended for it, thereby displacing or causing the removal of adjacent normal tissues, it could hardly fail to be productive of pathological results more or less severe.

The diagnosis of the condition is at all times exceedingly difficult, and in many cases impossible. As there is usually no enlargement or bulging of the tissues overlying the affected part, its existence is not perceptible, and can therefore only be inferred from symptoms. These indicative symptoms may exist or not according to the extent of the hypertrophy. The extracemental growth is, in the nature of the case, of very gradual formation. In its earlier stages, therefore, or where the enlargement is confined within moderate limits, there may not be sufficient interference with adjacent tissues to perceptibly disturb the equilibrium of health or ease; but where the growth assumes excessive proportions the disturbance caused by it is almost sure to manifest itself in a sense of greater or less discomfort and pain. This pain is doubtless due to the pressure of the increasing substance upon the main trunks of the nerves or some of their smaller branches, and it may be manifested locally where the cause exists or by reflex action in some other region more or less remote.

Tomes says:[1] "If the extremities of the fangs of a tooth be but slightly increased in size, either by hypertrophy of the cementum or by the growth of any other tumor, the dental nerve may be thereby disturbed, and hence sympathetic pains may be induced in any of those parts with which the nerve is connected." When the pain is local it may find expression in increased sensitivity due to pulp-irritation, or in a general tenderness or soreness to touch due mainly to irritation, and hence increased thickness of the pericemental membrane. Usually, when the pain is in a sense localized, it is not confined to a definite spot, but appears to cover a certain area large enough to include a number of teeth, and manifesting itself in an expression of general uneasiness and discomfort rather than in actual pain.

In many cases, however, hypercementosis is not accompanied by any local discomfort, but is responsible for sympathetic pains in other organs which are in themselves free from any local disturbing influences. Tomes[2] mentions the case of a lad admitted to the hospital for epi-

[1] *Dental Surgery*, p. 244.

[2] *Loc. cit.*

lepsy: "The usual remedies were tried for six weeks without effect. His mouth was then examined, and the molar teeth in the lower jaw were found to be much decayed, and of some of these the fangs only remained. He did not complain of pain in the diseased teeth or in the jaw. The decayed teeth were, however, removed, and the fangs of each were found to be enlarged and bulbous from exostosis. During the eighteen months that succeeded the removal of the diseased teeth he had not a single fit, though for many weeks previous to the operation he had two or three per day. As there was no complication of maladies, and as the trouble immediately subsided upon the removal of the teeth, there could be no doubt as to the cause of the disease." He also mentions the case of a policeman who was subject to fits, and who was greatly relieved by the removal of an inferior wisdom tooth that was affected with caries and exostosis.

Prof. Abbott[1] relates the case of a lady who for ten years had suffered excruciatingly from facial neuralgia. Medical help failed to relieve her, and her surgeon decided to sever the facial nerve upon the side that seemed most affected. Not gaining relief from this, another surgeon in another city operated in a similar manner upon the opposite side. This likewise failing to relieve her, she at last consulted her dentist, who located the cause of her trouble in one of her teeth. It was removed and relief immediately followed.

The writer recalls a somewhat similar case in his own practice where the patient (a lady) had suffered for many years with facial neuralgia. On examination many carious cavities were found, but none of the pulps had lost their vitality, neither was there soreness in any of the teeth. The cavities were filled and all calcareous deposits removed from the teeth. The pain continuing, its source was sought for, but could not be found. As, however, she had never lost any of her teeth, and as the wisdom teeth seemed very much crowded in their position, she was advised to have one of the lower ones removed, in the hope that it might be found to be hypertrophied and prove to have been in part the cause of the trouble. It was extracted, and the roots were found to be greatly enlarged. This brought her such a measure of relief that the opposite one was also removed, with the result of almost entirely curing her trouble.

A far more serious case of sympathetic disturbance resulting from hypercementosis is mentioned in the *Dental Cosmos*[2] as having been reported to the Buffalo Medical Association. A gentleman had suffered for many years from what was supposed to be neuralgia, which finally produced insanity. While in this condition he was brought to a dentist to have a tooth extracted. With great difficulty and by the application of extraordinary force the tooth was removed, when the roots were found to be largely hypertrophied, although the crown was sound. The neuralgia immediately ceased, and the patient was soon restored to health.

[1] *Cosmos*, vol. xxviii. p. 673.

[2] Vol. iii. p. 231.

REFLEX NEUROSES ASSOCIATED WITH DENTAL PATHOLOGY.

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The design of the following pages is to present a collection of those clinical cases, medical, dental, or neurological, which show the mutual influences and interactions of the teeth and the other structures of the body. It is hardly supposed that the several hundred cases here cited or referred to include every case that might be found by an exhaustive examination of all medical literature. On the contrary, it is hoped that this tentative essay may elicit references to cases we have overlooked, and, what is more important, that it will serve to secure the reporting of many new cases.

The simplest lesson to be found in any one of these cases—and one that is immensely emphasized if they be reviewed *en masse*—is one that is hardly recognized at its true value by the dental surgeon or by the general practitioner; it is this: 1, a pain in a tooth by no means indicates that that tooth is the seat of the source of the trouble: it may be in another tooth or in other tissues near or remote; 2, dental disorders may induce pathological conditions in other parts of the body or in the nervous structures themselves without the existence of any subjective intimations of pain in the teeth on the part of the patient. In other words, one may have toothache in the brain, the ear, the stomach, or the hip-joint, or one may have headache, gastralgia, etc. etc. in the teeth.

To explain the mechanism and derangement of mechanism by which this is rendered not only possible, but frequent, does not constitute a part of our task. In other parts of these volumes may be found a presentation of the elementary principles of the nervous and muscular tissues that are concerned. To readers interested in the subject it is unnecessary to epitomize the well-known anatomical and physiological details regarding the control and co-ordination of peripheral organs through the complex system of sensory, motor, vaso-motor, trophic, and secretory nerves. The understanding of the mechanism of a simple reflex act is also elementary and generally well known. A centripetal or afferent current travels from an irritated point toward a centre, and reappears as a centrifugal impulse which excites activity either in muscular, glandular, vascular, or secretory tissues. Sometimes the efferent impulse ends in an inhibitory apparatus; sometimes this last is centrally located, and the afferent impulse ends there. The centre thus transforming a centripetal into a centrifugal impulse may be subordinate—*i. e.* located near the structures controlled—or such a centre

may be joined by commissural fibres to other and higher co-ordinating centres, either in the cord, the medulla, or in the still higher and more representative parts of the encephalon.

It is clearly evident that the normal reflex act consists in such a distribution of the efferent impulse that the inciting irritation shall be accurately answered; that is, that such motion of muscles, such dilatation or contraction of blood-vessels, such stimulation or inhibition of glands, etc., shall result that, in biological language, the organism shall correctly react to the environment and meet its stimuli in such a manner as to ensure the healthful activity of the organism. Every example in our list of cases shows a derangement of this healthy ideal. To take the commonest example: there is a palpable failure of proper distribution of efferent impulse when delayed or difficult dentition sets up destructive lesions in the eye or ear. Any attempt to trace out specifically the mistaken routes of the nervous currents, the reasons of their deroutation, and the rationale of the disordered processes is in the present state of neurology either impossible or highly unsatisfactory. To help our minds we may crudely picture the central nervous system, and especially the medulla, as a sort of intricate switch-board of a large telegraphic office where are focalized myriad wires from all parts of the compass. When in normal action, the connections are such that a message from any peripheral point is shunted to its proper receiver, transferred to another wire, or sent into other and higher offices. Subordinate ganglia and spinal centres may be looked upon as relay or local stations, with limited authority and power, but which in extreme or important cases must refer to a more central authority. Now, most of the pathological instances gathered here seem to be the results of a disordered state of affairs at the switch-board—viz. the medulla oblongata. As far as concerns any adequate comprehension of the mysterious workings of the medulla either in health or disease, we are very much like an individual wholly ignorant of, and standing before, the switch-board and the unheard-of telegraphic machines.

The questions involved are of the profoundest interest and importance, but are little understood even by the best investigators. Volumes have been written concerning the theories of counter-irritation and reflex neuroses. We are not to add to the number. We shall only note that in attempting to locate the source of trouble in such cases we must remember that either of two processes may be present: either the cerebral mechanism may be solely at fault, resulting in an error of judgment on the part of the patient because of the switching of a message to the wrong receiving-centre; or the reflected irritation, returning by a false route, does in fact superinduce either a reflected neurosis or such a lesion in the peripheral tissues that they become the certain source of inflammation and pain. Whether a specific case belongs to one or the other of these classes is a question for refined diagnosis.

The practical lesson to be derived from it all is far more clear. Dentists must be on their guard against a number of sources of error in diagnosis and treatment that have heretofore been insufficiently recognized. These cases demand of the dentist a wider knowledge and a more general training than up to the present time have been considered

necessary; they show how subtilely and how frequently a slight derangement of nervous function produces the most unexpected consequences in the most unexpected places; they illustrate the lesson that meets the general practitioner at every turn, that the body is a multitudinous variety of units bound together into an interdependence by a nervous system whose easily-induced derangements may create quick havoc in strange places and by unintelligible ways. In this connection it is worthy of note that the two senses, seeing and hearing, are by far the most frequently set upon and injured by the reflex neuroses starting from the teeth. Thus the aurist and the ophthalmologist must unite with the dental surgeon, and he with them, in the advancement of their respective sciences—sciences that are henceforth proved to have much in common.

It is hoped that this collection of clinical cases will more forcibly impress upon both the dentist and neurologist the lesson that the teeth and their pathological states sustain intimate relations with all portions of the body, and will lead to such a recognition of overlapping fields and interlocking realms of study as will result in the relief of immeasurable suffering.

The simplest division of the cases is—1, into those in which the reflex current originating elsewhere is located in the teeth—reflex odontalgia, either of peripheral, cerebral, or systemic source; and 2, those where the source of the mischief is in the teeth, but which results in pathological conditions of other structures peripherally or centrally located.

I. REFLEX ODONTALGIA.

A. Of Peripheral Origin:

1. Dental;
2. Nasal and ocular;
3. Visceral.

B. Of Cerebral Origin:

1. Thrombi, tumors, and inflammatory processes;
2. Hysteria.

C. Of Systemic Origin:

1. Malaria;
2. Gout;
3. Syphilis, constitutional conditions, etc.

II. REFLEX NEUROSES OF DENTAL ORIGIN.

A. Affections of Peripheral Organs:

1. Ocular;
2. Aural;
3. Muscular;
4. Visceral;
5. Trophic and vaso-motor.

B. Affections of Nerves and Subordinate Nerve-centres:

1. Facial and other neuralgias;
2. Pareses and paralyses;
3. Tetanus.

C. Affections of the Cerebral Centres:

1. Headache;
2. Epilepsy;
3. Hysteria;
4. Chorea;
5. Insanity.

Before proceeding to a consideration of reflex odontalgia, the causes of local odontalgia will be briefly described.

LOCAL ODONTALGIA.

"Odontalgia" literally means pain in a tooth, but the term shall be employed in this connection to embrace all those painful states of the teeth excited either by local or general causes. The characteristics of odontalgic pain, its intensity, duration, periodicity, etc., will vary in individual cases and according to the nature of the particular condition giving rise to it, and need not be dwelt upon in this connection.

Although it is beyond the scope of this article to discuss at any length the nature of odontalgia and the various dental conditions which may give rise to its occurrence, yet it may not be considered inappropriate to allude briefly to the local pathological conditions chiefly concerned in exciting odontalgia before considering it as an effect of morbid states, both local and systemic, and excited through reflex action.

Of the pathological conditions connected with the teeth which most frequently give rise to pain may be mentioned the following:

1. Superficial caries;
2. Deep-seated caries;
3. Exposed pulp;
4. Congested and inflamed pulp;
5. Dead and putrescent pulp;
6. Nodular dentine in pulp;
7. Inflammation of the peridental membrane;
8. Fracture of the crown.

In very rare instances an apparently sound and healthy tooth will become the seat of severe and continuous pain which for the time resists amelioration from the application of any of the remedies usually employed. Generally, however, such a tooth, if the intensity of the pain does not necessitate its removal, will be found within a limited period to be responsive to local irritants, such as sweet, sour, hot, or cold articles, when brought into contact with some circumscribed spot upon the crown, the response manifesting itself as acute but temporary pain. The cause of this morbid condition is but imperfectly understood, and its pathological significance is only fully appreciated when the sensitive surface yields to some destructive agent resulting in molecular disintegration or caries. That the organic structure of the tooth has undergone some change which diminishes the molecular union previously

existing between it and the inorganic is doubtless true; and that this modification renders the tooth sensitive and the inorganic portion an easy prey to the destructive influence of an acid oral secretion is a theory well sustained by facts.

SUPERFICIAL CARIES.—With certain temperamental idiosyncrasies and predispositions superficial caries causes considerable local pain, and especially so when food becomes impacted in the cavity or is retained in contact with the dentine until fermentation increases its irritative properties. This pain, due to an unusual susceptibility to impressions or to an exalted sensibility of the dentine, is probably accompanied by an increased vascularity of the pulp, both being due to the loss of enamel-covering, as they both subside without treatment when the cavity is properly prepared and filled.

DEEP-SEATED CARIES.—When the cavity is deep-seated the same conditions exist as in the previous cause, and the same symptoms manifest themselves, though perhaps in a more intense degree. Under such circumstances it is difficult to discriminate between the pain thus occasioned and that due to pulp-exposure; but by drying the cavity and filling it temporarily with cotton saturated with sandarac varnish or with gutta-percha the condition is readily determined. With pulp-exposure the pain continues unabated, while when the pulp is not exposed, even though the lamina of dentine covering it be very thin, the pain subsides and the tooth becomes comfortable.

EXPOSED PULP.—The pain from this cause may be continuous or temporary, varying with the temperamental or constitutional peculiarities, and according to the extent and length of time of exposure. In many cases pulp-exposure may continue for months without giving rise to pain except when hard substances are brought into contact with it.

CONGESTED AND INFLAMED PULP.—Pain in a tooth from a markedly inflamed and congested pulp without exposure, or in a tooth free from caries, is of a peculiarly persistent and throbbing character, increased by stooping or assuming the horizontal attitude. The fact that the pulp is contained in an unyielding case or chamber is largely the cause of this severe and continuous suffering when it becomes the seat of inflammation; and the inability to be freed from the influence of the exudative products makes death and decomposition inevitable.

DEAD AND PUTRESCENT PULP.—When there is a free egress for the gases and decomposing débris of a dead pulp, there is usually no local pain; but if the avenue of exit for this offensive material be closed up, even for a limited period, the most excruciating pain is induced, which, if not relieved by an artificial opening into the pulp-chamber, will within a very short time be increased by an apparently elongated tooth, this giving great pain on pressure and being usually followed by an alveolar abscess. This condition, so unfortunate, is often followed by disfigurement and by physical prostration rarely surpassed by that resulting from any other local inflammatory condition.

NODULAR DENTINE.—Nodular dentine when located in a dental pulp surrounded by an unbroken and unyielding wall is at times the cause of local pain. This is usually periodic, and between the paroxysms entire immunity from discomfort is enjoyed. Much more fre-

quently these nodular masses induce pain in the terminal filaments of other branches of the fifth nerve, rather than in the filaments which are connected with them.

Inflammation of the Peridental Membrane.—The pain induced by this pathological condition varies much with the exciting cause and the extent of the inflammation. When it occurs independently of a dead and decomposing pulp, the pain occasioned by it amounts to little more than unremitting discomfort, and frequently yields to local bloodletting or other mild antiphlogistic remedies. When the periodontitis arises from a dead and putrescent pulp, the pain becomes exceedingly severe, and unless the pulp-chamber be opened for the exit of gas and decomposing products, an alveolar abscess with all its accompanying suffering must be expected.

Fracture of the Crown.—A blow upon the teeth occasionally results in a fracture of the crown, with or without exposure of the pulp. As a result of the injury there may be also partial dislocation of the tooth. Both of these conditions may be the cause of severe pain in the tooth. The treatment of such a condition will be suggested by the extent of the injury.

I. REFLEX ODONTALGIA.

By reflex odontalgia we mean pain in teeth that are not in reality the seat of the original pathological condition. The primary source of the pain may be in other teeth or it may be in any other organ of the body near to or remote from the teeth. The former condition may be illustrated by the very common phenomenon of reflex odontalgia of dental origin —*i. e.* where the pain in one tooth arises from diseased states in another tooth. A tooth apparently sound, not even showing sensitiveness to percussion or to heat or cold, may be either the inciter or the apparent seat of the pain. In just the same way irritation in other structures, either nervous or organic, and apparently in any part of the body, may be the cause of a reflected sensation of pain in the teeth.

The causation of many of the cases we shall cite being of peripheral origin, it would be very instructive and interesting to be able to trace the routes by which the centripetal impulses reach the nerve-centres before being reflected outward upon the teeth. But in the present state of anatomical and physiological knowledge such an inquiry would be impossible and fruitless. Our design at present being not to attempt any explanation of these phenomena, but to present the cases themselves for others to philosophize upon, we proceed at once to their consideration. We shall first bring forward those cases that are caused by irritation in peripherally-located organs, next those of cerebral origin, and lastly those of general or systemic origin.

A. Odontalgia of Peripheral Origin.

1. Of Dental Origin.

The group of cases of odontalgia in which the sensation of pain is located in a tooth near to or remote from the seat of disease is commonly

said by dental writers to arise from sympathy—a term, we may add, wholly without significance or physiological warrant. The physiological process cannot be different from that in other reflex neuroses, and because the reflected irritation returns to contiguous instead of to distant organs, there arises no justification for employing the mystical language of the affections. That an irritation of the nervous connections of one tooth may set up an odontalgia that the patient locates in another tooth, whilst the inciting tooth may be either painful or not,—this is a fact long recognized by all dental surgeons, and needs no further setting forth. Its illustration by cases would be a work of supererogation. An instance or two will suffice.

Friedberg[1] alludes to a case where a patient suffering for twelve days begged to have the second and third molars of the right side extracted. Both were sound, but the inner incisor was carious, though indolent to percussion; this was extracted and the odontalgia at once ceased. Other patients in his practice who would not allow the designated teeth to be extracted, but went elsewhere and had those extracted they thought were aching, found no relief. The pain still continued in the same spots whence the good teeth were taken, and only when the suspected teeth were removed did the odontalgia cease.

Dr. Lauder Brunton cites[2] the case of a family servant, which will be alluded to again, who had been suffering severely from a very severe temporal headache, and at the same time a severe toothache. He did nothing for the headache, but applied a pledget of cotton soaked in carbolic acid to the suffering tooth. No relief at all followed. Finally, word came to him that the girl had changed the pledget of cotton from the decayed molar that seemed to her the aching one to another hollow but painless tooth, when both the headache and the toothache vanished as if by magic.

2. Of Ocular and Nasal Origin.

That there have not come to hand more quotable cases illustrating these kinds of neuroses may either arise from the possible fact that morbid conditions of the eye and nose do not frequently result in pain which the patient locates in the teeth, or it may be that physicians have not been sufficiently and accurately observant of the fact. The non-existence of many illustrative cases argues nothing or next to nothing as to the non-existence of a causal relation. Very often it only needs more precise observation to detect facts that appear almost as if made to support a theory. However, if there are not many cases illustrative of ocular and nasal diseases as causative of odontalgia, the very common fact of odontalgia of a very painful and often persistent character being consequent upon surgical operations upon the nose is well recognized, and proves the close relationship. Such a case has lately come under the writer's personal knowledge, where a lady suffered extremely with toothache for several days after undergoing a slight operation in the nasal chamber.

It is also well known that catheterization of the nasal ducts frequently gives rise to dental neuralgia—a phenomenon which may be explained

[1] *Virchow's Archiv*, Band xviii.

[2] *St. Barthol. Hosp. Reports*, vol. xix.

by the fact that the nasal duct receives its innervation from branches of the anterior dental nerve.

Dr. Galezowski[1] is of the opinion that ocular injections and other pathological conditions are as often the cause of dental neuralgia as the reverse. He cites a case where iritis, with external inflammation of the eye and epiphora, had existed for fifteen days, coexisting with great dental neuralgia on the side of the affected eye. A dentist had successively extracted two molars eight days previously, not only without any relief either of the ocular or dental affections, but with an exacerbation of both. Leeches to the temple, instillation of a solution of atropine, with an internal administration of quinine, gave speedy relief both from the iritis (the exciting cause) and from the dental symptoms. Five months afterward the patient reappeared with exactly the same affection both of the eye and teeth, and was again cured by exactly the same means.

Dr. D. F. Jones records[2] the case of a boy into whose orbit a slate-pencil one and three-quarters of an inch in length had been driven by a fall. During its removal there was but slight hemorrhage, and the surgeon states that "the operation was performed without the influence of chloroform or any anæsthetic, and the bitterest complaint that the little patient made during its performance was that I was making his tooth ache. On being asked which tooth was aching, he referred the pain to one of the grinders of the upper jaw, which no doubt was caused by the pressure of the deep-seated extremity of the pencil while endeavoring to remove it, on the infraorbital nerve which supplies these teeth."

Pain in Teeth and Ear from Inflamed Eye.—Jonathan Hutchinson publishes[3] the following case: "A young man, the subject of acute ulcers of the cornea from injury, with hypopyon, chemosis, and much pain, complained that his eye made his teeth and ear ache: had never heard it mentioned so definitely before. Here we have an instance in which a pain certainly beginning peripherally induced pain in two other distinct and somewhat distant peripheral parts."

3. Of Visceral Origin.

Of the peripheral sources of reflex odontalgia, by far the most generally admitted and best illustrated are those proceeding from the disorders of the viscera of the abdominal cavity. Gynecologists have often noticed that toothache is frequently associated with uterine affections, and the general practitioner, as well as the dentist, has perhaps more frequently found it to be bound up with disorders of the alimentary canal. It would indeed be strange if such were not the case, in view of the close anatomical connection of the origins of the pneumogastric and trifacial nerves.

Alimentary Canal.—Dr. Lauder Brunton,[4] referring to the connection of the teeth and the alimentary tract, says: "We know that the pain of toothache is often at once remedied by a brisk purgative,

[1] *Journal d'Ophthalmologie*, tome i. p. 606.
[2] *Lancet*, 1859, vol. i. p. 359.
[3] *London Medical Mirror*, Sept. 1, 1869.
[4] *Op. cit.*

although the tooth remains in the same condition, the purgative having so altered the organism that it no longer responds in the same way to the irritation of the tooth. I use here the vague term *organism* in place of using the more definite one 'nervous system' or 'cerebral centre of sensation,' because we do not at present know the exact mechanism by means of which brisk purgatives produce such an effect."

Dr. C. N. Pierce has communicated to the writer a case occurring in his practice where a man, æt. 30, who had never been troubled with neuralgia, suffered for a week with severe pains in his face, though more particularly in his teeth. The pain usually became worse in the evening and continued all night, effectually precluding sleep. There was no condition of the teeth that would account for the severe pain. Upon inquiry it was learned that the patient's bowels had not been opened for a week or more. Free purgation gave complete relief.

Dr. J. W. White, in an article upon the "Systemic Causes of Odontalgia,"[1] thus alludes to the influences of the alimentary canal and bladder in the production of pain in the teeth:

"An attack of dyspepsia is by many more quickly recognized by subjective sensations in the teeth than by a special epigastric disturbance."

"In sea-sickness and in sick headache the nausea is sometimes preceded by intense discomfort in the teeth and jaws; sometimes by furious facial neuralgia, which promptly disappears after emesis."

"Hunger will with some people excite marked sensations of discomfort in the teeth. A case in point is that of a friend of the writer who in a convalescence from typhoid fever was seriously annoyed by painful sensations in two of his molar teeth whenever he became hungry; instant relief followed after swallowing food. These uncomfortable feelings would rouse him from sleep, and could not be allayed except by the introduction of food, if only a cracker, into the stomach."

"No one can recall the 'queer' feeling experienced, especially in youth, in the teeth, from a distended bladder, without recognizing a sympathetic relation between them. Intense dental neuralgia sometimes precedes or accompanies the passage of a biliary or renal calculus.

"The writer has met with a case of vesical irritability in which a very annoying sensation was caused in the teeth when the patient, after sitting or reclining, assumed the erect posture. This sensation was most strongly marked in the morning after a night's rest, and was coincident with the touch of the feet to the floor."

Uterus.—That morbid conditions of the uterus in both the pregnant and non-pregnant state very commonly cause odontalgia, both in diseased and sound teeth, is a fact which has long attracted the attention of dentists and obstetricians. Beyond the mere fact, however, that there is a close relationship between these two remote structures, nothing definite is known. There is no direct connection through the intermediation of nerves between them that physiologists are aware of, and yet it is indubitable that some such connection must exist to explain the occurrence of symptoms both in uterus and teeth which stand to each other in the relation of cause and effect. Future researches into the

[1] *Dental Cosmos*, 1872, p. 551.

more intimate arrangement of the nervous system and the course and distribution of its fibres, and a more thorough acquaintance with the laws of reflex action, will no doubt reveal a structural basis for the manifestation of phenomena which are now alluded to in a mystical way as sympathetic. A few illustrative cases will suffice to show how disordered states of the uterus reflect themselves upon the teeth in the form of pain.

Dr. Garretson relates[1] the case of a woman, æt. 35, who had complained of odontalgia in a bicuspid tooth of the lower jaw which had persisted for a period of nine weeks. As the pain had been unbearably severe and the tooth carious, it had been removed, but without any apparent benefit. In the absence of any lesion in the mouth to account for the pain, a general examination of the system was instituted, when it was discovered that the inner surface of the fundus of the uterus was ulcerated. Its cure was soon followed by a disappearance of the toothache.

Odontalgia of Pregnancy.—Dr. Storer relates[2] the following cases of neuralgia of the dental and gingival nerves occurring during the pregnant state: The patient in the first case was a young woman, æt. 20, of good health and physique. "She was four and a half months gone with her first child. Her general health had been good, and until the present she had never suffered from any form of neuralgic pain. She reported excessive toothache of nearly two months' standing; that it commenced in the left side of the lower maxilla, but then affected both sides of the jaws; that during the whole period she had been under the charge of a physician, and had been thoroughly and actively treated by anodynes local and general, by antiperiodics, purgatives, fomentations, and counter-irritants; that a tooth, apparently the only carious one she had, had been extracted ten days previously; and that it had been proposed to remove others, to which she would not consent,—all without relief. . . . . She was ordered a fragment of pellitory-root, pyrethrum, as a direct gingival stimulant, though horseradish would probably have answered the purpose, and on the second day presented herself cured. There had been no return of the malady, save a slight attack which was relieved by the same treatment. Patient was confined Feb. 3d, and is doing well."

Case II.[3]—"A. Z—— applied for treatment early in last May. Patient had suffered for several weeks from severe neuralgic pain throughout the left of the upper jaw, at times lancinating in character, at others more dull, but never wholly absent; the general health was decidedly affected, as evidenced by the state of the circulatory, digestive, and nervous systems. The teeth on inspection were all sound; there was no heat or swelling of the gums, no tenderness or increase of pain on pressing them." This patient was instantly relieved, and remained well for a period of five months (at which time there was no return of the trouble), by an injection of ten drops of the Edinburgh solution of the bimeconate of morphia into the gums.

Odontalgia occurring during Parturition.—Dr. S. W. Caldwell pub-

[1] *System of Oral Surgery*, 4th ed., p. 860. [2] *Atlanta Med. and Surg. Journal*, 1859.
[3] *Boston Medical and Surgical Journal*, Oct., 1859.

lishes[1] the details of a very peculiar case of odontalgia occurring during parturition which was related to him by the patient, a very intelligent woman, the mother of five children. She stated that her periods of gestation had been marked by nothing unusual; her labors had been natural and of about eight hours' duration. During the last labor, after suffering about an hour, the pain suddenly left the back and womb and appeared in a tooth that had given her pain occasionally during the past few months. The pain, like that which had been felt in the womb, was paroxysmal in character. Upon the arrival of the attending physician he placed a pledget of cotton soaked in chloroform in the tooth, when the pain was instantly relieved, only to appear again in the back and womb. The effect of the anodyne soon passed off, and the pain returned to the tooth, which was relieved again and again by the chloroform. During this time no progress had been made in the labor. Twelve hours had passed, though her former labors had terminated in six and eight hours. As she was becoming exhausted, she desired to have the tooth extracted. This was done, and the child was born in an hour.

Inasmuch as the extraction of a tooth during pregnancy has frequently caused abortion, the question naturally arises as to the advisability of such an operation for the relief of those cases of severe and harassing toothache which are sometimes met with, and the conditions which would render such an operation justifiable. This is a question of considerable moment, and has been the subject of much discussion by dentists and obstetricians. It would be impossible to lay down any positive and inflexible rule which should govern the practitioner in all cases that might come under his care. Each case would require separate and special consideration, and its management would depend upon the severity of the pain, its continuance, its effect upon the general health, and the possibility of the pain itself producing abortion through reflex action in highly-susceptible patients.

Dr. Hughes,[2] in a discussion of this subject before the St. Louis Medical Society, states the conditions which should determine tooth-extraction during pregnancy in the following words: "It is simply a question of individual temperaments, of conditions of the patient, and of the existence of centric or eccentric irritation, the existence or non-existence of central or peripheral irritation. And if a pregnant woman is extremely hyperæsthetic, and you can find a focus of origin for it in the peripheral irritation of a decayed tooth, there would be no impropriety in the majority of cases, I apprehend, in the removal of that decayed tooth. If in a condition of general nervous excitation, especially if centred in the brain or cord, you have any form of spasmodic display, and you find a possible peripheral source of the irritation, I think the general sentiment of the profession would concur in the propriety of removing that possible source of peripheral irritation."

[1] *Mississippi Valley Med. Monthly*, Jan., 1885.
[2] *St. Louis Medical and Surgical Journal*, 1882.

B. Odontalgia of Cerebral Origin.

1. Thrombi, Tumors, and Inflammatory Processes.

That thrombi, tumors, inflammatory processes, etc. at the base of the brain, within its substance, or about the cortex may produce odontalgia is a proposition which finds but little support in the records of clinical cases. Nevertheless, such instances have been shown to exist. That a greater number of such cases has not been recorded may be that, because such an origin is not commonly suspected, it could not have been observed, though actually present. Many cases of facial neuralgia caused by morbid processes around the origin of the trigeminal nerve or by diseases in the cervical portion of the spinal cord are very frequently attended with more or less severe odontalgia, the cause of extreme suffering, and which is overlooked and masked by the severity of the general pain.

Cerebral diseases, such as insanity, softening of the brain, etc., occasionally are associated with odontalgia, and stand in the relation to it of cause and effect. Thus it is well known that attacks of insanity alternate with attacks of odontalgia, the former condition subsiding at once upon the appearance of the latter, and the reverse.

Coleman[1] mentions the case of an insane lady who repeatedly troubled him and other practitioners "to remove her sound teeth, on account of the uncomfortable sensations which she referred to them." Dr. Stellwagon[2] also states that he gave great offence to a military officer by refusing to extract some perfectly sound teeth which were the seat of severe odontalgic pain. The patient shortly after began to exhibit symptoms of softening of the brain. It is not unlikely that in this case the pathological process involved some of the filaments of the trigeminal nerve. Rosenthal[3] states that on several occasions he has "seen old men—sixty to seventy years of age—suffering from melancholia complicated with neuralgia of the dental branches: these cases must be attributed to senile changes in the tissues (osseous canals or arteries)."

Dr. Benson relates[4] the case of a young man who suffered from severe pain in a molar tooth, due, as was shown subsequently, to an abscess at the origin of the fifth nerve. The details of the case are as follows: "The young man suffered for a long time from headache on the right side, and at the same time from toothache, which brought him to desperation, as it was said. When asked which tooth it was that caused him pain, he always pointed to the first upper molar on the right side, but the most careful examination of the tooth failed to discover any indication of disease. The patient demanded, nevertheless, that the tooth should be extracted. After some days his desire was fulfilled, but no relief followed the extraction. He could not sleep either night or day, and died four days after the operation in violent pain, which was held to result from inflammation of the brain. The opening of the dead body showed nothing remarkable in the mouth or

[1] *Dental Surgery and Pathology*, p. 395. [2] *Ibid.*
[3] *Diseases of Nervous System*, p. 209.
[4] *British Journal of Dental Science*, August, 1867.

cheek. . . . . The opening of the cranium showed the brain sound, but in the exit of the fifth nerve and in the nerve itself a small swelling, of yellow color, was seen of the size of a grain of mustard-seed, not so large as a hemp-seed, containing pus and placed on the side from which the aching tooth had been extracted."

2. Hysteria.

Whether that strange medley of phenomena comprised under the general term "hysteria" is dependent upon any pathological change in the nervous tissue, or whether it is an evidence of a purely functional disturbance, it is quite certain that it frequently gives rise to or is associated with odontalgia.

Dr. Richardson[1] was among the earliest to call attention to this factor in the production of toothache, and stated that it was more common than ordinarily supposed, and laid down several rules for distinguishing a toothache from this cause. He says: "In the cases where hysteria thus shows itself the pain may take three kinds of positions: it may extend to several teeth; it may be fixed in one or two teeth which are sound; it may be pitched in a tooth which is more or less carious. I believe, however, as a general rule, that hysterical toothache fixes on a tooth which is diseased."

In the simpler forms of hysteria pain in the teeth is of frequent occurrence, and no little skill is required in determining which tooth is the seat of the trouble. It is indeed quite capricious in its manifestations, shifting from one tooth to another, and at times disappearing altogether, especially when the patient's mind is diverted to other topics and away from the teeth. The toothache which is such an unfortunate complication of pregnancy is believed by Dr. Richardson to be connected with the hysterical tendency, and dependent in great part upon it. In these cases the pain, which is usually excruciating, localizes itself in a diseased tooth, and will persist in the jaw even after the tooth has been extracted; or if the teeth are sound the pain will be more general and often diffused along the margins of the gums. The following cases will illustrate this form of odontalgia:

Odontalgia due to Hysteria.—Dr. Morton Smale[2] relates the following case: "Miss J——, a young lady aged nineteen, came complaining of toothache in the second lower molar on the right side. On examination it was found to be very much decayed, and as it was very sensitive to pressure, showing some inflammation of the peridental membrane, and as there was not room for the dens sapientiæ, it was extracted under nitrous oxide gas, and the patient was told to come again to have some teeth filled that were decayed. When she came pain was complained of in the first molar next to the one extracted. This was excavated ready for filling, and some carbolic dressing put into the cavity. The pain continued, and the tooth was sensitive in the same way as the other: she could not eat on it, and the slightest touch of an instrument, even on the healthy surface of the tooth, was felt. The pain was constant day and night, and of a dull, heavy character. The patient wished very

[1] *Diseases of the Teeth*, p. 85. [2] *British Medical Journal*, 1880, vol. i. p. 362.

much that the tooth might be extracted. The gums were ordered to be painted with a solution of tincture of iodine and tincture of aconite. A calomel-and-opium pill was given at night, and a general tonic was prescribed. The pain, however, continued; nothing gave relief. At this time my suspicion was aroused; and, pretending to tap with an instrument a tooth in the upper jaw, I really did tap the bottom one, but no pain was felt in either tooth. This I repeated several times, with the same result. I felt convinced that the pain was entirely hysterical, and on inquiry found from her relatives that she was a very hysterical subject and had been under treatment about a year before. Miss J—— is a full grown, well-developed woman, and of a peculiar lethargic, unenergetic disposition, and rather anæmic, but on the whole enjoying good health. She is regular in all her habits, and the catamenial periods are regular. This is the second case of the kind that has occurred in my practice."

Hysterical Odontalgia during Pregnancy.—Dr. Richardson[1] relates this case as an illustration of his view that the toothache of pregnancy is frequently, if not always, connected with hysteria: "A lady was engaged in preparing a ballroom for visitors in the evening. She had been for some days before in indifferent health, with tendency to hysterical paroxysms. In the midst of her occupation she suddenly uttered a piercing scream, and in an instant was frantic with agony. There was no mistaking the fact of suffering, for every limb shuddered and cold sweat bedewed the cold face, which was distorted with pain. In the midst of her agony she tore up everything in her way, and neither reason nor persuasion could for a moment influence the frantic expression of a torture which seemed unendurable. The seat of the pain was a carious tooth in the upper jaw, the first molar—a tooth which for a long time past had given no anxiety or trouble. From this point the pain seemed to extend all over the body, but in the tooth it was concentrated. On the application of chloroform to the cavity of the tooth the pain as suddenly ceased, leaving the patient as free from pain as at any previous period. Afterward, however, for the succeeding one or two weeks, there was occasional smart returns of the ache, with equally rapid subsidence on the application of a narcotic. This is a very fair representation of the worst form of hysteric toothache during pregnancy."

(For further illustrations of toothache caused by diseased conditions of the uterus, and as occurring during pregnancy where there was no evidence of hysteria, see p. 442.)

C. Odontalgia of Systemic Origin.

It has long been known that the various systemic conditions caused by the poisons of malaria, gout, syphilis, etc., while having no special and remarkable tendency to produce pain which the patient localizes in the teeth, are yet frequently provocative of severe and obstinate forms of odontalgia. There can be no doubt that these kinds of reflexes exist, as the following cases will demonstrate. It is well known that in malarial districts toothaches of a distinctly periodical character are frequently

[1] *Op. cit.*

observed, which are only relieved by antiperiodic remedies, such as quinine and arsenic.

In the gouty and rheumatic diatheses the pain which usually localizes itself in the joints not unfrequently selects one or more teeth for its local expression. In such cases the pain assumes the specific characters of these diseases.

The most noteworthy cases that have come to our notice, and which illustrate the preceding remarks, are given below without further comment:

1. Odontalgia of Malarial Origin.

Dr. Flagg reports[1] the following case: "Mrs. ——, æt. 30, sanguino-bilious temperament, applied for relief from a constant pain in the left superior maxilla, which had lately assumed the complication of periodic odontalgia located in the sixth-year left superior molar. She had been under treatment for the pain in her face for eighteen months, with alternate relief and return of the trouble, but with no permanent benefit. The patient suffered from the tooth indicated some two years previously, when the pulp had been devitalized and a good foil plug introduced. She informed me that several years before she had had intermittent fever." The metallic plug in this case was removed as a possible source of the irritation. Owing to the periodicity of the pain and the history of malarial poisoning, the patient was placed upon quinine and nux vomica. At the expiration of three weeks the patient was completely cured.

Periodical Odontalgia—Malarial (?).—Dr. Wade cites[2] the following case: "Matilda W——, æt. 17, a domestic servant, was admitted on Nov. 1, 1872. For three months she had had very severe pain in the teeth. At first those of the upper jaw were mostly affected. During the three weeks preceding her admission the pain had been confined to the left half of the lower jaw. The pain always precluded all hope of sleep if it came on in the evening. The teeth were very defective in the upper jaw: on the right side all but the incisors were wanting; on the left, the first bicuspid and first molar were absent. In the lower jaw, on the right half the first and second molar, and on the left half the second molar, were wanting. All that remained of the other teeth were simple stumps, much decayed and discolored. The general health of the patient had been pretty good; the various functions were well performed. She was ordered to take at once a draught of twenty grains of sulphate of quinine, with dilute sulphuric acid, in an ounce of water. The draught produced cinchonism, with speedy and great relief to the pain, which in the course of thirty-six hours had entirely subsided."

2. Odontalgia of Gouty Origin.

At a meeting of the Brooklyn Dental Association, Dr. Latimer[3] mentioned the following case of toothache, which was to him of much interest: "The patient was some forty years of age, unmarried, and in delicate health. A few weeks before she had a violent toothache, which

[1] *Dental Cosmos*, vol. iv. p. 476.
[2] "Birmingham Hospital Reports," *British Medical Journal*, 1873.
[3] *Dental Cosmos*, May, 1865.

after a few hours was suddenly exchanged for a gouty pain in one of her great toes. Only the day before he had been sent for by her to remove a loose superior second bicuspid. She had been afflicted with a severe pain in the breast, which was suddenly transferred to the tooth named and resulted in alveolar abscess. In the first instance the toe and foot remained swollen and sore for several days."

Dr. Harris reports[1] this case: "Mr. W——, æt. 40, for fifteen years the victim of gout, came to me for odontalgia. The first right upper molar was carious, but the pulp not exposed. Ten or twelve days before each attack of gout, recurring every five or six months during the last five years, this tooth was the seat of a peculiar grinding, lancinating pain, becoming gradually more severe, but ceasing entirely as the gouty symptoms came on. It returned as these subsided, and continued for two weeks. Filling the tooth gave only temporary relief, and it was found necessary to extract it.

3. Odontalgia of Specific Origin.

Syphilis, anæmia, and the constitutional disturbances that precede the eruption of the exanthematous diseases at times give rise to painful sensations which are referred by the patient to the teeth. An example of such constitutional disturbance is shown in the following instance, given to the writer by Dr. C. N. Pierce, the case being that of a young lady who had been suffering for several days from severe pain in all the teeth, though they were apparently free from disease. The gums were very much swollen, tender to the touch, and presenting an appearance as if there was general periodontitis. A few days later the trouble entirely disappeared upon the appearance of the eruption of measles.

II. REFLEX NEUROSES OF DENTAL ORIGIN.

Having briefly passed in review those local and systemic conditions which are reflected to the teeth, giving rise to odontalgia, it now remains to consider more closely those affections of neighboring and distant organs that may be set up by pathological conditions of the teeth as primary inciting causes. The reason of this derangement of function and the manner of its proceeding are in these cases as indefinitely determined as in the preceding instances: its essential feature, however, as we have seen, consists in some abnormal relation between afferent and efferent nervous impulses. The centripetal irritation travels inward from the morbid peripheral point, and the resultant centrifugal impulse does not follow the usual and normal tracts outward, but results in effects that cannot at present be brought within the control or exact expression of known laws.

It is a reasonable supposition that the laws of nerve-force correspond to the same general laws as other forces. As no force is ever lost, but must, when it disappears, appear as some other mode of motion, so peripheral irritation continually travelling inward is either reflected over and outward by other routes to other organs, or is stored up in inter-

[1] *Dental Surgery.*

related centres until morbid function results in them. In case it is reflected back, the continuous innervation of a structure superinduces in it some morbid process; if it is not reflected back, there results such disorders as headache, insanity, neuralgia, or those periodical discharges of nerve-force which are termed epileptic.

The intricate connection of the nuclei of the trigeminal nerve with the nuclei of origin of the various motor cranial nerves affords an anatomical explanation for the great variety and extent of many of the reflex disturbances that arise from dental irritation. But why the irritation from morbid conditions of the teeth should in one case result in wry neck or facial spasm, and in another in blindness, in deafness, in chorea, in dyspepsia, in epilepsy, or in mania, is an inquiry at present unanswerable and beyond the purposes of this paper. But in this connection there is one thing beyond question: even the few cases here presented must leave no room for doubt that morbid conditions of the teeth may be, in other organs far removed, the fruitful source of troubles whose real origin was hardly to be suspected. If in a large proportion of the cases cited it should be found that the supposed result was simply a *post hoc*, and in no sense a *propter hoc*, there would still be a great gain in the alleviation of suffering and the progress of therapeutics, both dental and general, from the recognition of the true etiology of the few remaining cases where the dental irritation was undoubted.

But there are strong reasons for believing that even if some cases supposed to have, at last are found not to have, such causal relation, there are yet multitudes of cases wherein such a relation, though actively existing, is not recognized, and, notwithstanding all treatment, the affection persists, simply because its real causation is not perceived. Every practitioner of dentistry or of general medicine constantly meets cases of obstinate and inexplicable affection whose *raison d'être* seems past finding out—cases that yield to no therapeutics, and whose continuance is a standing rebuke to the profession and a source of misery to the sufferer. It is of course by no means contended that all such diseases are of dental origin, but it is believed that in some instances such an origin may be present, and that the recognition of that supposition would result in scientific progress.

In view of the inconsequential nature of the nervous response to morbid irritation of the dental and alveolar nerves, no anatomical or scientific order has been attempted in arranging the following illustrative cases, but we have considered those occurring in other peripheral organs in the order of their removal from the inciting causes, proceeding thence to such neuroses as affect nerves and subordinate nerve-centres, and lastly to those connected with the higher co-ordinating centres themselves.

A. Affections of Peripheral Organs.

1. Ocular Disorders.

That pathological conditions of the teeth may, by the intermediation of the nervous system, result in ocular disorders is, up to the present time, a proposition hardly entertained by ophthalmologists. The matter is not even alluded to by Stellwag von Carrion and Solberg Wells,

while Graefe and Saemisch do not more than refer to the work of Schmidt, of which the details are given below. It may therefore be readily imagined that upon turning to ophthalmological literature for proof of the above proposition, we have not been met by a large number of clinical cases. The cases given below in brief are certainly not all that may be reasonably supposed to exist in medical literature: they are such as without extraordinary effort could be collected by running through the periodical literature easily at hand. Nevertheless, it must strike any one as not a little remarkable that there should exist such a body of independent and unanimous testimony pointing to the fact above stated, and yet to know that it is almost completely ignored by the medical profession. It will be remarked that the cases illustrate the noteworthy fact that these ocular troubles are of no special tissue or type of inflammation. Every part of the eye has, in the few illustrative cases that have come to our notice, been found to bear the brunt of the abnormal condition of the nerve-centres. In a general way, the functional disturbances predominate, and, unlike the aural troubles to be alluded to later, the instances that may be classed as of a vaso-motor disturbance are in a minority.

As to the routes of the afferent and efferent impulses, it is at the present stage of physiological science impossible to give anything like a definite answer. There can be little question, however, that the rebound of the centripetal irritation takes place from a deeper centre than the ciliary ganglion or any anastomoses upon the cavernous sinus.

There can be little doubt that there are trophic nerve-fibres running from the cerebrum to subordinate ganglia, and thence to the tissues, whose function, apart from the blood-supply regulated by the vaso-motor system, is to govern the metabolism of the tissues. It is quite certain that such fibres pass to the eye, and that such a ganglionic centre exists in the Gasserian ganglion; but comparatively few of the disorders given below can be classed as distinctly related to trophic disturbance. The indication seems rather to be that these ocular affections are largely inhibitory in character and cerebral in origin—a fact readily understood when we consider that the central origins of the fifth nerve are intimately and anatomically associated with the centres of every motor nerve proceeding from the region of the fourth ventricle, and especially with the third, which last is again united under the aqueduct of Sylvius with the fourth and sixth.

We shall begin our illustrative cases with those of the more external and noticeable functional disorders—viz. the pareses of the ocular muscles from inhibition of their appropriate centres.

Strabismus, Ptosis.—Mr. Hancock reported[1] some years ago the following case: "H. R——, æt. 29, was admitted into the Royal Westminster Ophthalmic Hospital suffering from divergent strabismus and ptosis. The strabismus had existed for three years, the ptosis only for about two weeks. The left eye was closed. The mischief came on suddenly, without pain either in the head or eye. Examination of the mouth showed a carious condition of two molar teeth in the left side of the upper jaw. The teeth were extracted, though the patient assured

[1] *Lancet*, 1859, p. 80.

him they caused her no pain. In two days the ptosis was better; in two days more it had assumed an intermittent character, the eye being now open in the morning, but toward noon the lid drooped until evening, when it assumed its proper position. She was ordered ten grains of quinine daily. Four days later the ptosis was cured and the strabismus better—so slight, indeed, as not to require an operation. Three weeks later she was discharged cured."

Ptosis from Decayed Teeth.—Mr. Power[1] reports a case of double ptosis occurring in an unmarried woman æt. 33: "She was the subject of marked ptosis in both eyes, the ciliary edges of the upper and lower lids being in complete and even apposition on both sides. There was no wrinkling of the skin or other sign of spasm of the outer portion of the orbicularis. She was quite unable to open her eyes, and when pressed to try to accomplish this there was marked spasm of the orbicularis oculi, together with contraction of the anterior bellies of the occipito-frontalis muscles and horizontal wrinkling of the forehead. On opening the lids with the fingers considerable orbicular spasm ensued, but when this resistance was overcome the condition of the globe was found perfectly natural, its movements being more free, of normal extent, and visual acuity $\frac{20}{20}$. There was no sign of paralysis. The spasm of the orbicularis was most marked when the patient knew she was being observed and when her attention was directed to it. She, however, complained of a 'nipping' sensation coming on at irregular times and referable to this spasm. This condition had only come on a fortnight before." Upon the supposition that this was a case of hysterical ptosis, all moral and medicinal means were employed for her relief without avail. Thinking that the paresis might be due to irritation arising from the presence of diseased teeth in the mouth, they were removed. The ptosis at once improved and steadily diminished. After ten days the palpebral fissure was wide enough to expose more than half the cornea, and she was able to see to read and to find her way about the hospital without throwing her head back.

Dr. Edward T. Ely reports[2] the three following cases of paresis of the ocular muscles. These instances are particularly instructive, as the relation of cause and effect between the dental irritation and the ocular defects seems to have been thoroughly established:

Paresis of Orbicularis Muscle—Irregular Spasm of Ciliary Muscle—Monocular Diplopia.—"Male, aged 26. Complains that vision of the right eye has suddenly become blurred, and that he sees double with that eye. No pain or redness. Pupil small and movable. Fundus normal. Has paresis of right orbicularis. Lids cannot be completely closed and the eye is very watery. V. $= \frac{20}{50}$, and with $+ \frac{1}{36}$ c. $180° = \frac{20}{20}$. A careful examination of the teeth shows nothing abnormal. Patient was ordered to take mercury and iodide of potash, which he did for some time without benefit. One night he was seized with severe pain in one of his upper molar teeth. The next day the tooth was extracted, and an abscess which had formed about its root was evacuated. Paresis of orbicularis muscle, diplopia, and astigmatism disappeared immediately, and V. became $\frac{20}{20}$ without any glass. There

[1] *Lancet*, April 9, 1881. [2] *N. Y. Med. Record*, March 11, 1882.

was no doubt about the astigmatism in this case, as the vision was subjected to the most careful tests."

Paresis of Right Internal Rectus and Ciliary Muscles.—"Male, aged 33. Complains of blurring and 'confusion' of vision of right eye of a week's duration; no redness or pain. Size and movements of pupil normal. Fundus normal. V. $= \frac{20}{20}$ with $+ \frac{1}{60}$. Slight paresis of right internal rectus muscle. Slight paresis of accommodation, requiring $+ \frac{1}{16}$ to restore normal range. The root of the first molar tooth of upper jaw, right side, is denuded, roughened, and sensitive. Patient was referred to dentist, and was treated with mercury and iodide of potash (there being a syphilitic history) and by electricity. Part of the root of the tooth was removed and the remainder filled. The nerve of the tooth was found dead and the alveolar process absorbed, but there was extensive suppuration in the adjacent parts. The ocular paresis recovered immediately when the condition of the tooth was corrected a month later, the other treatment having been abandoned for some time previously."

Partial Paresis of Third Nerve.—"Female, aged 40. Complains of confused feeling in right eye, which she cannot describe; says it began with burning pain in the right ear and the right side of the head. No redness of eye. Pupil dilated and immovable, and accommodation partially paralyzed; opacities of both lenses. Teeth on right side are decayed and tender, and gums are in an unhealthful condition; advised to consult a dentist. After one week paresis of third nerve disappeared entirely after extraction of one tooth."

Lagophthalmus.—Mr. S. J. Hutchinson[1] related before the Odontological Society of Great Britain the case of a lady who had suffered for several months from a spasm of the left upper eyelid. The eyelid was drawn up by a constant spasmodic contraction of the levator palpebræ in such a manner as to expose the whole of the iris and a portion of the sclerotic. Several decayed teeth were removed. The patient was relieved from a neuralgia from which she had suffered, but the spasm of the eyelid was not lessened. A year later, the patient being in the same condition, Mr. H. again examined her teeth, and found as the only possible source of the irritation an amalgam filling in the left upper first molar. This was removed, and it was found that there was a minute exposure of the pulp, on which the filling had pressed. The tooth was removed, and this was attended with satisfactory results. The condition at once improved, and at the end of six months she was almost entirely well.

Copious Lachrymation.—Mr. D. Corbett relates[2] the following case: "A young girl, aged 15, subject to copious lachrymation on each occasion that she left the house for outdoor exercise. There was no outward manifestation of organic disease, the eyes looking brilliant and healthy; still, the moment she went into the open air the tears poured down her cheeks in the most distressing manner. . . . . After several months of suffering she was brought under my notice to ascertain if the teeth could in any way influence the condition of affairs. On examination I found the cuspidati of the upper jaw absent, though the dental arch

[1] *Med.-Surg. Rep.*, Nov., 1885. [2] *Transactions International Med. Congress*, 1881.

was perfect. Understanding that no teeth had been extracted from the child, I at once removed the first bicuspid on each side. Within one week a manifest improvement was observable, and within three months all inconvenience had passed away when the cuspidati made their appearance."

Neuralgia of Eyeball.—Mr. Hutchinson reports[1] the following case: "Mrs. Higdon, æt. 28, a woman somewhat enfeebled by nursing, came to Moorfields on Jan. 16th, stating that she could not see well with the left eye. I found that for a month past she had suffered from pain in the eyeball and in the forehead. The pain was severe, but not constant. It was clearly of a neuralgic character. The eye was watery and irritable. There was intolerance of light, and she could only read large capital letters. The intolerance of light was such that I could not well test her power of vision. She said she had had no toothache, but on examination I found a carious molar in the upper jaw which was tender to pressure. I desired her to have this removed. She did so, and returned to me a week later in great delight at having completely got rid of her symptoms. The eye was no longer irritable. She had no intolerance of light and she could read well. She stated that the pain in the eye and forehead ceased immediately after the extraction of the stump."

The following case is reported[2] by Dr. Dowse: "A gentleman of healthy appearance, æt. 23, consulted me in the spring of 1878 for a severe neuralgia of the left eyeball, influencing slightly, but only slightly, the brow. It came on usually about four o'clock in the afternoon, when the eye became intensely congested and the sight for the time almost obliterated. He had obtained advice from many medical men, but only with temporary benefit. He had been frequently asked if his teeth were sound, and so, to all appearance, they were. I carefully percussed each tooth from behind forward, and he experienced no pain until I touched the centre of the first bicuspid pretty sharply, when almost instantaneously the attack of neuralgia came on. The tooth was extracted, and there was an end of the matter. The fang of the tooth was diseased at its extreme end and the nerve was inflamed and thickened."

Dr. J. H. McQuillen also reported[3] a case of neuralgia of the eyeball, in which there was also considerable facial neuralgia. The pulp of the right upper cuspid was exposed. Several other teeth were also decayed. After their removal the patient had no return of the pain.

Sclerotitis.—Dr. C. E. Wright reports[4] a case of sclerotitis due to dental irritation: "The patient was a young woman, æt. 25, with circumscribed sclerotitis about the insertion of the external rectus muscle of the right eye. There had been no mechanical injury to the eye. The patient was experiencing no other difficulty, save a severe aching of the second molar tooth of the same side. There was profuse lachrymation of the right eye. Treatment produced no perceptible good until the carious tooth was extracted, when the inflammation subsided as if by magic."

[1] *Ophthalmic Hosp. Reports*, vol. iv. p. 383.
[2] *Neuralgia*, 1880, p. 21.
[3] *Dental Cosmos*, vol. iv. p. 316.
[4] *West. Journ. of Med.*, Aug., 1869.

Conjunctivitis and Sclerotitis (?).—Dr. Ely reports[1] the following case: "Male, aged 33. Complains of painful inflammation of left eye, which he has had for three weeks. Has had neuralgia of the left side of face most of the time for the past month. There is a patch of inflammation involving conjunctiva, subconjunctival tissue, and apparently the sclerotic at the lower and outer quadrant of the globe. It is about ten millimeters broad, and extends from the edge of the cornea to the retrotarsal fold. Its appearance is that of the affection ordinarily called episcleritis. There is lachrymation and localized ciliary tenderness. Pupil is small, movable. Vision and accommodation normal." The patient was advised to consult a dentist, who discovered an exposed pulp in a cuspid tooth. After it was devitalized the ocular inflammation and neuralgia disappeared within forty-eight hours. No other treatment was employed.

Inflammation of the Cornea.—Dr. P. D. Keyser reports[2] a case of corneal inflammation and beginning ulceration occurring in a young man aged 33: "The left eye became inflamed without any apparent cause. There was infiltration of nearly the whole cornea, with a small spot of beginning ulceration in the centre. There was little if any pain; anæsthesia of the cornea was present, as the touch of a feather or roll of paper was not felt. The usual treatment for inflammation of the cornea was continued for three weeks, but with no effect. On the last day of the third week the patient came to my office with severe toothache, and stated that he had suffered for months with it, off and on. Examination of the teeth showed the first molar on that side much decayed, with exposed pulp. At my suggestion the tooth was extracted, after which the cornea began to improve rapidly, and under ordinary treatment the infiltration was all absorbed and the cornea became clear again."

Dr. Galezowski[3] mentions the case of a child eighteen months old attacked three successive times with abscess of the cornea consequent upon the irritation of a new dentition. Simple lancing of the gums effected an immediate cure of the corneal abscess.

Phlyctenular Conjunctivitis, consisting in the appearance of small vesicles that soon rupture and form small ulcers, is attended with more or less intolerance of light, pain, and lachrymation. Children are most subject to it, though it occasionally occurs among adults, but in all instances among those who are ill-nourished and of a scrofulous or nervous temperament. While the pathology of this disease is tolerably clear, its causation in many instances is very obscure. In all probability it is due to some irritation of the terminal branches of the trifacial nerve. Many ophthalmologists are of the opinion that there is a direct causal relationship between this disease and the disorders incident to dentition.

Iridoplegia, or Mydriasis, is another condition of the eye which is very often due to reflex influences. It is quite a significant fact that the dilatation of the pupil is usually unilateral, and suggests the idea that the reflected irritation may have its origin in the terminal twigs of the tri-

[1] *N. Y. Med. Rec.*, March, 1882.

[2] *Dental Times*, Oct., 1870.

[3] *Journal d'Ophthalmologie*, tome i. p. 606.

facial nerve. Diseased conditions of the teeth might therefore play an important part in the etiology of this affection, and in those cases in which the cause is not apparent the teeth should always be carefully examined. Indeed, one case has been reported by Desmarres in which a complete cure was effected by the extraction of a carious molar.[1]

Failure or Loss of Accommodation.—This abnormal condition of the eye is very often dependent upon dental irritation. By accommodation is meant the power which the eye possesses of forming distinct images of near as well as distant objects upon the retina. This is accomplished by altering the convexity of the crystalline lens by the action of the ciliary muscle.

To ascertain the extent to which the accommodation might be impaired by dental lesions, Hermann Schmidt[2] tested the accommodation of 92 persons suffering from caries of the teeth, periostitis, neuralgia, etc. The design was to compare the accommodation of the eye upon the affected side with that of the sound side, and also with the normal acccommodation which, according to Donders, corresponds to the general average of eyes at the age experimented upon. Schmidt found only 19 out of the 92 to have a normal accommodating power, whilst 73 were decidedly deficient. In monolateral affections of the teeth the extent of accommodation of the eye upon the affected side was in 30 cases less than that of the other side, whilst in 51 cases there was no difference. In 9 cases the dental trouble was on both sides. This lessening of accommodation was most frequent in the young, seldom happening in those above thirty. There was diminution of accommodation in 17 cases out of 41 maladies of the superior maxillary, and 19 cases out of 39 maladies of the inferior maxilla. Only 8 patients were re-examined after relief of the dental affection, but in 5 out of the 8 there was an increase of accommodation. The lessened accommodation was, as a rule, also accompanied by increased intraocular pressure.

Glaucoma.—This term is applied to a morbid condition of the eye in which there is an increase in the intraocular tension of the eyeball. The normal tension, though varying within limits, is on the average about equal to twenty-five millimeters of mercury. The degree to which the tension may be increased beyond this is of course very variable. In the simple variety of glaucoma there is usually an absence of all external symptoms. Ophthalmoscopic examinations may show, in addition to the increased hardness of the ball, excavation of the optic disk and a diminution of the visual field. The relation of toothache and dental irritation to glaucoma simplex has been studied by Mr. Priestly Smith.[3] This observer made a series of tonometrical measurements to determine whether toothache ever causes a rise in the ocular tension. He measured the tension in sixteen persons suffering at the moment or recently from severe pain in the teeth. He found, however, no anomaly of accommodation in 15 out of the 16 persons examined, but admits that he "did not ascertain the state of refraction present, so that it is possible that the presence of myopia may have marked a retrocession of the near point

[1] Quoted by Mr. Power, *Med. Press*, Nov. 28, 1883.
[2] *Archiv für Ophthalmologie*, xiv. 1, p. 107.
[3] *Glaucoma, its Causes, etc.*, 1879, p. 10.

in some cases." Neglecting for the moment all errors attributable to this method, he found a distinct difference in the tension in the two eyes in 6 cases out of the 16. But in 3 of these the eye of the painful side was the *harder* of the two; in three others it was the *softer*.

A case of *inflammatory glaucoma*, following a severe attack of odontalgia, is recorded by Creniceau:[1] The patient was attacked with severe pain in one of his left molars which extended all over the left side of the face and to the eye and ear. On the following day the pain was better. On the succeeding night it returned in all its former severity and radiated to the right side. The patient was then seized with all the symptoms of acute inflammatory glaucoma. After several days iridectomy was performed, and the eye moderately compressed to prevent intraocular hemorrhage if possible. After four days of partial relief the pain returned in all its severity, followed by a large intraocular hemorrhage. After a month the blood was almost absorbed, but the patient could only distinguish light from darkness.

Amaurosis, Amblyopia.—These two terms are often used interchangeably, and signify a condition of the eye characterized by an impairment of the visual acuity without any perceptible ocular lesions. This impairment may exist in varying degrees of intensity. In the lighter forms of the affection the patient suffers merely from a diminution of the visual acuity, the chief difficulty being an inability to read small print. To this condition the term "amblyopia" is generally applied. In the graver forms the visual acuity may be so far diminished that the patient can but distinguish light from darkness, or in other cases the visual impairment may have proceeded so far that both the quantitative and qualitative perception of light may have entirely disappeared and the patient be wholly blind. It is now pretty generally admitted that the above conditions often result from the irritation reflected from diseased teeth, and almost wholly disappear after their extraction. Ophthalmoscopic examination seldom reveals any pathological condition in these cases, the appearance of the fundus being normal. The following cases are striking illustrations of the close relationship of amaurosis and dental irritation:

Amaurosis of Right Eye of Twelve Years' Duration cured by Extraction of Tooth.—Dr. De Witt reports[2] the following case: "Mr. J. P——, a merchant, æt. 31, of good constitution and health aways excellent, in the month of June, 1856, while in the act of firing a gun, first discovered that he was blind in the right eye. He had no pain in the eye at the time nor subsequently, neither were there any spectral illusions. Vision was lost without his being able to ascribe it to any cause. In this condition the eye remained for nearly twelve years; he could merely discriminate light from darkness, but nothing more. On the 24th day of December, 1867, while conversing with him, I inquired as to condition of his eye, and at the same time endeavored to ascertain the probable cause of the malady. Directing my inquiries to the teeth, I learned that some two months before his loss of sight he had had several teeth filled, and that not long after he had one of these teeth extracted

[1] *Klin. Mon. für Aug.*, 1866, August.
[2] *American Journal Med. Sciences*, 1868, p. 383.

in consequence of its aching. The other teeth had never given him any trouble. Upon examination I found a large cavity in the first bicuspid of the right upper jaw, which had been neatly filled with some kind of white metal. There was also a fistulous opening upon the alveolus opposite that tooth, and no doubt extending to its fang. He said there had been for a long time some soreness and tenderness at this point, and very frequently an abscess formed which he opened with his knife. Presuming that the amaurosis had its origin in an irritation of the nervus trigeminus distributed to this tooth, I advised its immediate extraction. Mr. P——, being naturally very timid, objected. I then removed the filling from the tooth in the hope of getting a counter-opening, by which I hoped the fistula might possibly close and the irritation be relieved. This result actually occurred. The fistula closed, the soreness of the alveolus subsided, and vision was gradually restored. An offensive mass came out of the tooth soon after the plug was removed. About three weeks subsequent to this (Jan. 12, 1868), when the eye had become nearly as good as its fellow, the soreness upon the gum recurred and vision simultaneously became blurred. On the 19th of January I extracted the tooth, when the blur immediately disappeared. At the present time (Jan. 28, 1868) Mr. P—— can see quite as well with the right as with the other eye, except in the discrimination of very small objects. There was no foreign substance at the root of the tooth; its interior was filled with pus, and the communication between it and the cavity had become closed."

Amaurosis from Toothache.—Wecker[1] relates the case of a seamstress who became wholly blind in one eye consequent upon severe toothache upon one side of the upper jaw. In a few days the vision of the other eye was entirely lost after a severe exacerbation of the dental affection. The pupils were large and reacted but slightly to light. Five carious teeth were extracted from the left side of the jaw, and upon coming out of the chloroform anæsthetization the patient's vision was somewhat improved in the left eye, and in five days there were complete restoration of normal vision in the left eye and quantitative perception of light in the right eye. Fourteen days later three more diseased teeth were extracted from the right side, followed by an immediate return of vision to the right eye, which became normal and perfect in a few days thereafter.

Delgado[2] gives the details of the following case: A boy, æt. 11 or 12 years, had become so amblyopic following an apoplectic attack that he could not count figures before his eyes. The ophthalmoscope showed extensive choroidal changes. Two carious teeth were noticed during an examination of the child, and these were extracted, with the result that the boy was at once able to see, and in three days could read the finest Jaeger type with ease.

A. G. Richter relates[3] the case of a woman who had been blind for many years regaining her sight for a short time after the extraction of a tooth.

Many other remarkable cases of amaurosis have been reported by

[1] *Annales d'Oculistique*, lv. p. 130. [2] *El Pabellon Medico*, No. 6, Feb., 1866.
[3] *Anfansgründe der Wundarzneikunst*, Bd. iii. p. 428.

Keyser[1] (6 cases), Hutchinson,[2] Hunter,[3] Galezowski,[4] Abbott,[5] Alexander,[6] Salter,[7] Lardier,[8] Sirletti,[9] Gaines,[10] Frühauf,[11] Skogsborg.[12]

Exophthalmos, the Result of Carious Teeth.—Dr. Weinberg reports the case of a woman who five weeks previous to presentation at the clinic had for several days experienced roaring in the right ear upon arising in the morning. This was succeeded by headache in the fronto-temporal region of the right side, and tingling sensations in the right eye, which soon became lancinating, whilst at the same time the eye became reddened and highly injected. For the last four days vision had become interfered with. Examination showed exophthalmos of the right eye, augmented intraocular tension (+1), conjunctival congestion, hazy cornea, and limited movements of the eye. The ophthalmoscope showed injection of the retinal vessels of the periphery, flakes in the vitreous, redness of the retina, hemorrhagic spots about the macula, and spots of choroidal atrophy. Various means—leeches, ointments, atropine, and internal remedies—were tried without avail to lessen the symptoms, especially the intense pain in and about the orbit and the chemosis. Upon inquiry by Dr. Galezowski (as was his habit under like circumstances) in regard to the condition of the teeth, two carious teeth and one stump were found. Extraction of the teeth at once gave great relief, and when, later, the stump was taken away, the chemosis, inflammation, pain, and exophthalmos disappeared.

2. Aural Disorders.

That aural troubles are excited through reflex action from irritation of dental nerves is a truth no longer questioned. The fact has become so apparent as to be well recognized by aural surgeons. Thus, out of 80 infants under fourteen months of age examined by Dr. Wreden of St. Petersburg, more than 80 per cent. had some form of ear trouble.[13] Sexton,[14] in reviewing his records of some 1500 cases, says he thinks "perhaps one-third owe their origin or continuance in a greater or less degree to diseases of the teeth." In the children of a large charitable institution, of the ages including the second dentition, Sexton found about 6 per cent. had otitis media purulenta, and a still larger number had some form of aural trouble. The same writer[15] has also called attention to the occurrence of otalgia and other forms of aural trouble as due to the irritation of carious and diseased teeth, and more particularly of pulpless teeth. He further says: "In the case of no dead (pulpless) tooth, however carefully treated and filled, can it ever be successfully demonstrated that a slight irritation is not constantly present, although no appreciable irritation may be experienced by the patient."[16]

[1] *Dental Times*, Oct., 1870.
[2] *Ophthalmic Hosp. Reports*, 1865, p. 384.
[3] *Amer. Journal Med. Sci.*, Oct., 1841.
[4] *Archives générales de Médecine*, t. xxiii. p. 261.
[5] *Dental Cosmos*, July, 1870.
[6] *Klin. Monatbl. für Augenheilk.*, Feb., 1868.
[7] *Lancet*, July 5, 1862.
[8] *L'Union médicale*, Dec., 1874.
[9] *Le Mouvement méd.*, Mai, 1878.
[10] *Brit. Med. Journal*, Dec., 1865.
[11] *Deutsche Vierteljahresschrift für Zahnheilkunde*, 1873.
[12] *Deutsch. Monat. für Zahnheilk.*, No. 1, 1885.
[13] Woakes, *Deafness, Giddiness, etc.*, p. 16, 1879.
[14] *Amer. Journ. Med. Sciences*, Jan., 1880.
[15] *N. Y. Med. Record*, Oct. 4, 1884.
[16] *Ibid.*, Nov. 8, 1884. For further information upon this subject, so important in all its bearings to both dentist and physician, see editorials in *Med. Record* for Oct. 4 and

Woakes, who has written an admirable monograph on ear affections, has accorded the fullest recognition to the dental origin of many aural diseases. In advising treatment of a child for inflammation of the ear, "the fons et origo mali," he always takes it for granted that the gums have been lanced, and he even goes so far as to say that "when brain symptoms develop themselves in an infant, it is to the ear that attention should primarily be directed. We have seen how readily, during teething, congestion and inflammation may arise in the drumhead, how by continuity of vessels this may spread to the cavity of the drum, and how this latter condition so readily becomes meningitis." Woakes gives it as his opinion that the route of the reflected nerve-current is through the vaso-motor branches of the otic ganglion, through the ganglion which supplies the nervi vasorum of the carotid plexus, and especially of the tympanic branch of the internal carotid artery. "The effect, then, of the irritating impression proceeding from the decayed tooth or swollen gums will be to excite waves of vessel-dilatation in the correlated area, the drumhead." Hence the tinnitus aurium, which is the noise of the distended vessels and rushing blood-currents; hence also the proliferative and suppurative processes. Whatever the method or character of the process, the fact is indisputable, and dentists possessing the requisite knowledge may honor both themselves and their profession, and at the same time relieve much distress, by keeping this fact before their medical and aural confrères. It cannot be doubted that much deafness is a result of unrecognized dental trouble in infancy; and as the condition of deaf-mutism is so often the sequel of ear lesions, it is highly probable that the great number of these pitiable objects in the charitable institutions might be lessened by so simple a matter as attention to the gums of children during teething.

The following cases will serve to illustrate the connection between dental irritation and aural lesions: Inflammation of the external auditory canal, either of the subacute or chronic variety, is not infrequently associated with dental irritation. The canal under such circumstances is more or less diminished by the swollen condition of the lining membrane, which is congested and covered with a viscid secretion. There are usually a sensation of fulness and pain, slight impairment of hearing, and otorrhœa. The discharge may be serous or purulent, continuous or intermittent, and last for months and years, resisting all medication. It is not improbable that the difficulty often experienced in arresting this form of otitis may be due to neglect of the physician in examining and treating morbid conditions of the teeth. Most clinical observers recognize dental irritation as one of the causes of otorrhœa.

Chronic Catarrhal Inflammation of the Dermoid Meatus during Teething.—Mr. Toynbee relates[1] the case of a child, æt. 9 months, who was brought to him on account of an offensive discharge from the ear. Two months before, during the eruption of several teeth, which made the child fretful and irritable, the discharge took place. At first it was

Nov. 9, 1884, and discussions of Dr. Sexton's thesis before the N. Y. Odontological Society in *Dental Cosmos*, Feb., 1885; and also a paper "Upon the Effects of Pulpless Teeth remaining in the Jaws," by Dr. Harlan, in *Dental Cosmos*, May, 1885.

[1] *Diseases of the Ear.*

small in quantity, but gradually increased, and became very offensive. After cleansing the canal it was found to be diminished one-half by swelling of the epidermis, which was denuded of its epithelium and somewhat redder than natural. The teeth having erupted, local treatment soon arrested the discharge.

Otorrhœa.—Mr. Hilton records[1] the case of a professional friend who had a morbid discharge from the auditory canal. He had also an enlarged gland below the external ear, the cause of which was not apparent, but was attributed to possible lymphatic absorption from the auditory canal. It was suggested by Mr. H. that the trouble in the canal was probably due to irritation caused by the presence of a decayed tooth. The tooth was removed, and all the local morbid conditions disappeared, and there was no return of the malady.

Dr. Benjamin W. Richardson states[2] that he has seen several instances of temporary deafness produced from inflammation of the auditory canal induced by irritation reflected from the teeth. The lining membrane when inflamed from this cause seldom ulcerates, but gives vent to a constant mucous or semi-purulent discharge, accompanied by pain, and even with temporary deafness. In extreme cases the drum membrane may become thickened and ulcerated.

Acute Inflammation of the Middle Ear, either of the catarrhal or purulent form, may result from dental irritation. The catarrhal form is very common and apt to occur in young children. The earache to which they are subjected is very often dependent upon this cause. The affection comes on suddenly during the eruption of a tooth, and is characterized by most excruciating pain, which is located primarily in the ear, but soon radiates all over the face and temporal region. In the milder forms of the inflammation free lancing of the gums, thus removing the source of the irritation, causes all the phenomena to subside in the course of twenty-four hours. Very often, however, an effusion into the middle ear takes place, serous or mucous in character, which lasts a variable length of time, but gradually becomes absorbed. The purulent form is more apt to occur among children of a strumous or scrofulous constitution; the symptoms are essentially the same, though more pronounced and followed by the formation of pus. The tympanic membrane becomes swollen and congested, and as the pus accumulates and bulges the membrane outward ulceration sets in, followed by a discharge of pus, and otorrhœa is established. This condition, being neglected, as it frequently is, becomes chronic. The structures of the tympanic cavity are destroyed and deafness results.

The fact having been established by clinical observation that these unfortunate results often arise during the period of the primary dentition, and are caused by it, both the dental and medical practitioner should institute a more careful examination of the gums and teeth in every so-called case of earache occurring in children. A more thorough appreciation of the relationship existing between the teeth and the deeper structures of the ear will result in a lessening of the number of cases of otorrhœa and subsequent deafness.

In adults the irritation caused by the eruption of the wisdom teeth

[1] *Rest and Pain*, Am. ed., p. 44.

[2] *Diseases of the Teeth*, p. 137.

may be reflected to the middle ear and excite acute otitis. Dr. Robert J. Cooper records[1] such a case: "A lad, æt. 17, was brought to him suffering with intense earache in the left ear and otorrhœa. Five weeks previous to this time he had had an acute otitis lasting for several days, after which the otorrhœa took place. The ear was sensitive to pressure, though there was no visible inflammatory redness or swelling. Examination of the membrana tympani revealed extensive perforation, and the handle of the malleus could be seen protruding into the meatus and lying against its upper wall. Upon the supposition that the teeth might be the cause of the affection, the mouth was carefully examined. The gums covering the wisdom teeth on both sides were swollen and hard to the touch, and particularly so on the left side. The age of the boy precluded the idea that the wisdom teeth were erupting and causing the trouble. They were therefore not removed. The symptoms, nevertheless, continued, and increased notwithstanding treatment. He began having cold shiverings in the evening, with coldness of the feet and hands; severe pain in the vertex of the head. The pain in the ear extended down to the shoulder, and during the paroxysms of pain the head was drawn to one side and had to be supported by the hand. This continued for one month, when both the right and left wisdom teeth came through and all the pain left the ear. Two days after the discharge ceased and the membrane began to cicatrize.

Otalgia.—Neuralgia of the ear as a distinct nervous affection, independent of any inflammatory symptoms or alterations of structure, is frequently caused by carious teeth. The pain is usually referred to the deeper structures of the ear, and is continuous in character, though at times there are distinct exacerbations. It most generally occurs with the decay of the molar teeth, and subsides as soon as they are treated or extracted. The following cases will show the relationship between these two affections:

Otalgia from Impacted Roots.—Dr. Bryson Delavan records[2] a case of otalgia due to an abscess around the impacted roots of a molar tooth on the opposite side of the jaw. The patient was a young girl, æt. 20, of good constitution and family history. She had always been in good health, with the exception of an attack of double otitis media when she was seven years old. Since then she had been slightly deaf in the right ear. Four days before the case was reported she began to have pain in the right ear, which was constant and throbbing, though at times lancinating in character. This condition became so much worse, and more especially at night, that almost complete insomnia resulted. There was no apparent cause for the trouble. The teeth were in good condition in the upper jaw. The right second molar of the lower jaw was carious, and the right wisdom tooth had not yet made its appearance. The wisdom tooth on the left side was through, but the second molar was wanting. The patient stated that this latter tooth had decayed and come out several years before. Upon being examined by a dentist it was discovered that the roots of the deficient second molar were impacted in the jaw, though completely covered over with mucous

[1] *Dublin Journal of Medical Science*, Sept., 1881.
[2] *American Journal of Otology*, 1881.

membrane. They were removed with considerable difficulty. At the extremity of one of the roots a sacculated abscess of extraordinary size was found. The wound soon healed up, and the otalgia quickly disappeared. Two months after there had been no return of the otalgia.

Otalgia from Dying Pulp.—Dr. Abbot, at a meeting of the N. Y. Odontological Society, related[1] the following case: "A lady had been under the treatment of an excellent aurist for inflammation and pain in the ear, but without being benefited. At the same time she was suffering from pain in a right lower molar which had been filled some fifteen months before. I found the pulp dying, and opened the pulp-chamber. At the moment it was penetrated the pain in the ear, which was at that time quite severe, left her, and in a few days' time the ear was perfectly well. It has given her no trouble since."

Otalgia.—Dr. H. C. Houghton at the same meeting related another case: A young lady had had some work done by a competent dentist, who reported that all her teeth were in good condition. After the work was finished she was seized with a severe attack of otalgia and odontalgia. There was no evidence of any inflammatory action. The dental work was unobjectionable. In a short time, however, the reflex disturbance gradually subsided.

Dr. Garretson[2] mentions two cases of otalgia from dental irritation. One case of five weeks' duration was caused by a nodule of denture in the pulp of a wisdom tooth. There was no local cause for the trouble in the ear. In the other case the eruption of a wisdom tooth was the exciting cause. Extraction of the offending teeth in both the cases was followed by immediate relief.

Von Troltsch[3] mentions having seen two cases of pure otalgia nervosa caused by carious teeth. In one case the pain in the ear was entirely relieved by the extraction of the tooth, and in the other after a suitable filling had been put into the decayed cavity.

Sudden and temporary deafness has frequently been observed to accompany many cases of dental irritation. As an examination of the ear reveals an absence of structural alteration, it is probable that the disease partakes more of the nature of a functional disturbance, an inhibition of the appropriate nervous centres. In the present imperfect state of our knowledge of the pathological processes of the internal ear, and as to the location of the auditory centres, it is very difficult to even attempt localizing the pathological processes here involved. The subjoined cases will illustrate this form of ear trouble:

Deafness.—Mr. Catlin[4] records the following case: "A lady in the second stage of consumption consulted me concerning a diseased right lower molar. She had had for about three months diffused acute pains in the tooth, ear, and side of the neck. When I saw her she had become deaf for four days. The inflamed tooth was extracted, and her hearing returned within an hour after the operation."

Neuralgia, Otalgia, and Deafness.—Dr. Flagg reports[5] the following case: "Mrs. M——, æt. 35, bilio-lymphatic temperament, of fair gen-

[1] *Dental Cosmos*, Feb., 1885.
[2] *System of Oral Surgery*, 4th ed., p. 861.
[3] *Die Krankheiten des Gehörorganes*, S. 238.
[4] *Trans. Odontological Soc.*, vol. iii. p. 308.
[5] *Dental Cosmos*, vol. iv. p. 476.

eral health, had been treated for facial neuralgia complicated with otalgia, complete deafness in the left ear, and occasional otorrhœa during seven months. Treatment had been of no avail. The pain, which was of an unbearable, wearing character, had been intermittent, but without distinct periodicity; it had gradually passed into constant uneasiness, with occasional exacerbations. These were relieved by the discharge from the ear, but the deafness was continued and complete." Examination of the mouth in this case revealed an inflamed and ulcerated condition of the alveolus around the wisdom tooth. Its removal and subsequent treatment entirely relieved the patient of all her symptoms.

Deafness cured by Extraction of a Tooth.—Dr. Luther Campbell records[1] the following case: "Mrs. A——, æt. 38, presented herself about five months ago for the purpose of having all the superior teeth in her mouth extracted for the purpose of obtaining an artificial set. The teeth were extracted in the following order: right second molar, right second bicuspid, four incisors, and left cuspid. Immediately after the removal of the cuspid tooth the patient remarked that she could hear now with the left ear. She had been *entirely* destitute of hearing in that ear for upward of *three years*, having lost the faculty while attending church. . . . . She said that after the removal of the cuspid tooth a sensation followed like a current of air passing in at her ear, which lasted for several minutes. Immediately afterward she recovered her hearing. Upon examination of the teeth, I found them much decayed and all affected with alveolar abscess, especially the right molar and incisor teeth—the bicuspid and cuspid not so much so. I have frequently seen the patient since, and her hearing continues good."

Deafness, Tinnitus, Neuralgia.—Dr. C. H. Burnett mentions[2] the following case: "A brother practitioner asks for treatment of hardness of hearing, tinnitus, and a peculiar sense of discomfort in the left ear. His statement is that he believes he may have aural catarrh; and this view is strengthened somewhat by the appearance of the membrana tympani, which is lustreless, opaque, and retracted. But nothing being said about the teeth, the usual treatment for aural catarrh is instituted and the patient is apparently better for a short time.

"In the course of a year all the old symptoms are worse, and some new ones, more disagreeable, are added. There is considerable neuralgia in the post-auricular region, with a constant and pounding tinnitus, which is likened to the noise of a trip-hammer, synchronous with the pulse, and a peculiar tapping noise not synchronous with the pulse. The latter is about ninety times a minute, and seems to the patient to be attended with motion in the ear. It seems as though some power pulls on a little string fastened to his drum. There are also laryngeal irritations in the form of ear-cough, which, though not excessive, seem to the patient to depend on the continued annoyances in the ear. *All of these symptoms came on and kept up during excessive pain in the first molar tooth in the upper maxilla on the same side.* The patient now states that ten years before this molar tooth required filling; that ever since more or less discomfort has been experienced in and around it; that inflammation in its neighborhood has frequently occurred with

[1] *Dental Cosmos*, Jan., 1875. [2] *Specialist and Intelligencer*, Nov. 1, 1881.

more or less intensity, and the aural symptoms had first shown themselves about six months after the tooth was filled. He also states that all dental disturbances ever since have been attended by aural discomforts, which have gradually increased until the final attack, three months ago, when both aural and dental sufferings became nearly intolerable; an abscess formed near the tooth; and at last the tooth was extracted, *with instantaneous relief from all forms of tinnitus, tapping sounds, and neuralgia in the ear, the ear-cough, which had been marked up to this time, ceasing and the hearing becoming very much better.* The tooth shows great and peculiar disease at the root, and the socket is necrosed, so that its cavity is thrown into that of the socket of the second molar behind it by destruction of the partition between them."

Deafness, Tinnitus, Itching, and Pain in the Left Ear for Two Years.—Dr. Roosa records[1] the following interesting case: "The patient, æt. 40, had deafness, tinnitus, and itching in the left ear for two years; has had neuralgia of the jaw, face, shoulder, and arm of the left side for some time; dizziness and nausea for some time; has had a great deal of neuralgia before, and is subject to headaches; hearing distance of her right ear, $\frac{40}{48}$, left ear, $\frac{10}{40}$; tuning-fork heard on vertex, but in left ear. Bone-conduction better than aërial on each side. Patient has a hard swelling high upon the gum above last molar tooth of left side. She has had an ulcerated tooth there with similar swelling, requiring lancing farther forward. Present swelling increasing in size, but not tender. Right membrana tympani opaque; fair light spot, fair position; left membrana tympani opaque: fair light spot, fair position. The diagnosis here is neuralgia and trophic changes in tympanum from irritation of the fifth nerve."

A case of sudden deafness due to dental irritation, and which was relieved by appropriate treatment, has also been recorded by Sexton.[2]

Dr. Robert T. Cooper has called attention[3] to a form of deafness that is a frequent concomitant of severe and irregular eruption of the wisdom teeth. It is a slow, progressive, and intractable form of chronic otitis, for the relief of which neither the extraction of the teeth nor any form of medication has been, in his experience, of any benefit. The irritation excited by the abnormal evolution of the tooth results in an insufficient innervation of the deeper ear structures, and causes not a temporary, but a permanent, alteration in structure. In those cases in which it can be shown that the deafness made its appearance slowly and insidiously at the period of the wisdom-tooth eruption, Dr. Cooper thinks that nothing can be gained by its extraction. He regards this form of deafness as in no way distinguishable from the chronic deafness described by Toynbee under the head of "rigidity of the mucous membrane of the tympanum," and by Roosa as "proliferous deafness." The following cases are given in illustration:

CASE I.—"The Rev. C. H. B——, æt. 50, consulted me, June, 1881, for deafness, which has existed, he says, for some twenty years. He cannot think why it should have come on, but on careful inquiry I find that the wisdom teeth were erupted with great difficulty; that the left lower

[1] *Diseases of the Ear*, p. 564.
[2] *N. Y. Med. Rec.*, Oct. 4, 1884.
[3] *Dublin Journal of Medical Science*, Sept., 1881.

wisdom tooth 'grew into the cheek,' was decayed, and had to be extracted; that about twelve years ago the same occurrence took place with either the right or left upper wisdom tooth—he forgets which—and that it too had to be extracted, after having had years of trouble with it."

Case II.—"Miss F. S——, a young lady of 25 years, consulted me, Dec., 1880, for deafness of the left ear. The hearing of both ears, however, is imperfect ($\frac{7}{35}$ right, $\frac{3}{35}$ left); the left membrane is of a dull opaque hue, the malleus handle being prominent and very white; the right is in appearance normal. Inflation improves the hearing of the right, has no effect upon the left ear. F. S—— states herself to have been partially deaf for six years, but never sought treatment for it till a year and a half ago, when, after a right wisdom tooth was extracted, her left ear began to get noticeably dull. She then consulted a German aurist, who put her case down as one of ordinary catarrhal otitis. The left upper and the left lower wisdom teeth have not made an appearance."

3. Muscular Disorders.

Under this head will be considered only those instances of active contraction or spasm of voluntary muscles brought about by reflex irritation from the teeth. With the exception of some of the ocular muscles, the only muscles known to be affected with spasm are the facial group, the masseter and the sterno-cleido-mastoid innervated by the facial, the motor root of the fifth, and the external branch of the spinal accessory nerves respectively. That these muscles should remain in this state of active contraction for an indefinite period without becoming exhausted is somewhat difficult to explain, but is in all probability due to the fact that the muscular fibres as a whole do not contract simultaneously, but successively, so that while one set is in contraction another set is in repose. This explanation of the condition of these muscles receives some support from what is known of the sphincter muscles, in which this successive contraction of the muscular bands has been shown to exist. It is to be regarded as due to an incessant outflow of nerve-force from the centres, kept up by the continual peripheral irritation. Although it is well known that the central origins of the motor nerves innervating these muscles are closely connected by commissural fibres with the origin of the fifth, it is wholly unknown why the peripheral irritation of the trigeminal branches should in one instance be transferred to the facial and in another to the spinal accessory. The muscular disorders thus arising are facial spasm, trismus, and wry neck or torticollis.

Facial Spasm.—Spasmodic contraction of the superficial muscles of the face is due to irritation of the facial or portio dura nerve. The affection may be clonic or tonic, and is generally confined to one side of the face. The irritation may be central, though it is very frequently of a reflex nature associated with diseased conditions of the teeth. In the clonic variety, often called painless facial tic, the spasms may occur at intervals of a few minutes or hours; during the attack the muscles of the face are in constant movement, producing a profound change in the

expression. In the tonic variety the spasm is continuous. The face is very much distorted upon the affected side from the contraction of the orbicularis palpebrarum, the levator anguli oris, and associated muscles. The following case related to the writer by Dr. C. N. Pierce, illustrates this form of the affection:

Facial Spasm from Indurated Gum.—A child, aged 14, was suddenly seized with marked spasmodic contraction of the superficial muscles of the right side of the face, giving to it a peculiar distorted appearance. Although the contraction was continuous, there was from time to time twitching of individual muscles. No apparent cause being present for the trouble, the mouth was carefully examined. It was found that the inferior second molar of the right side had not erupted, owing to an indurated condition of the gum covering it. After liberation of the crown by excising the indurated tissue, the muscular spasm soon subsided and entirely disappeared.

Although this is the only case I am able to record, other instances have doubtless been observed, as both Rosenthal[1] and Hamilton[2] mention dental caries as among the causes capable of giving rise to this affection.

Trismus.—Trismus, or tonic contraction of the masseter muscles from irritation of the motor root of the trigeminus, is a frequent accompaniment of dental disease. The irritation arising from the irregular and painful eruption of the wisdom teeth seems to be the most fruitful cause in the production of the spasm. The affection is chiefly of the tonic form, though the clonic has occasionally been observed. The muscles are in a state of extreme rigidity. The patient is unable to open the mouth even with the employment of forcible means. The duration of the spasm is indefinite, continuing as long as the cause persists. The subjoined cases illustrate the nature of trismus as caused by diseased teeth:

Trismus from Carious Tooth.—A. Reeves Jackson publishes the following case:[3] "Maria L——, æt. 18, called upon me and gave the following history: Five weeks ago she commenced suffering with pain, which she referred to the wisdom tooth in the left side of the lower jaw. The same tooth had frequently been the seat of pain during the past five years. The pain decreased in severity after the first few days, but she noticed a difficulty in opening the jaws which gradually increased, and at the end of three weeks she could not separate them at all. When she made a strong effort to open her mouth the attempt, if in any degree successful, was followed by a sudden snapping of the teeth together. Occasionally these spasmodic actions were observed without any attempt having been made to open the mouth, but they were infrequent and of short duration. The general health of the patient was good. On examination I found the trismus complete, and that any attempt to separate the jaws was followed by sudden spasm and pain. Inserting a finger between the cheek and the gum, I observed that the least pressure over the diseased tooth produced pain, although it did not excite any spasm. A painful spot was detected also just in

[1] *Dis. of the Nervous Syst.*, p. 197. [2] *Pepper's Syst. of Med.*, Vol. V. p. 462.
[3] *American Journal of the Medical Sciences*, April, 1869.

front of the left ear, at which point there was some swelling. I administered, by inhalation, a mixture of ether and chloroform until sufficient relaxation of the muscles was produced to permit the extraction of the tooth, which was accomplished with some difficulty. A few spasmodic movements of the jaws were observed during the next four days, but they diminished in frequency and violence, and soon disappeared entirely."

Chronic Trismus from Impaction of Lower Dens Sapientiæ.[1]—"A. B——, æt. 23, with large teeth and comparatively small maxillary bones, had been suffering for the past three years from recurrent attacks of pain and swelling within the mouth and in the angles of the lower jaw, where the wisdom teeth were deeply imbedded and unable for want of room to come into place. For four months there had been persistent 'lockjaw,' which at first alarmed the patient and his friends exceedingly. It supervened suddenly, and appeared to be occasioned by contraction of the left masseter muscle. At present the patient could barely force a tobacco-pipe between his incisor teeth. I directed him to use Maunder's screw-gag to force open the jaws, and after its employment for a week I was able to extract the second molar tooth of the left side, the wisdom tooth being altogether out of reach. The posterior fang of this tooth was much eroded by absorption. The trismus did not recur, and the jaw had lost all its stiffness in four-and-twenty hours."

Trismus from Overcrowding of the Teeth.[2]—"A gentleman, aged 30, has suffered with lockjaw and pain under the right ear for the past twelve months. He could separate the jaws in front for only about half an inch. He attributed the mischief to cold, and had been subjected to various kinds of treatment, including leeching, blistering, etc., without benefit. Upon careful examination I observed that his teeth were much crowded and wedged closely together, particularly in the upper jaw, and concluded that to be the cause of suffering. I accordingly requested Mr. Alfred Canton to extract one of the anterior molar teeth from the upper jaw. The tooth was very large, but perfectly sound, and the patient returned home in the course of a week cured."

Cases of trismus due to essentially the same cause have been reported by Barker,[3] Howard,[4] Clum,[5] Gaine,[6] Germain,[7] Colin.[8]

Wry Neck, or Torticollis, is essentially a spasmodic contraction of the sterno-cleido-mastoid and trapezius muscles. The affection may be unilateral or bilateral, involving either one of the muscles or both. The muscular spasm may be continuous, lasting for weeks and months, or it may be paroxysmal, the duration of the attack varying from a few minutes to several hours. In unilateral spasm of the sterno-cleido-mastoid muscle the head is somewhat rotated, the occiput is drawn down toward the clavicle, and the chin is directed to the opposite side. Among the many causes capable of producing this disease must be mentioned morbid states of the dental and alveolar nerves.

[1] J. A. Salter, *Dental Pathology and Surgery*, p. 261.
[2] Mr. Hancock, *Lancet*, 1859, p. 80.
[3] *Dental Cosmos*, Oct., 1872.
[4] *Ibid.*, March, 1869.
[5] *Dental Times*, April, 1873.
[6] *Brit. Med. Journal*, 1878, p. 844.
[7] *Gazette hebd.*, 1863, x. 7, p. 103.
[8] *Études cliniques de Médecine militaire.*

Mr. Hancock has related[1] the following case: "A young woman was brought to me at the Charing Cross Hospital with wry neck, the head being drawn down nearly to the right shoulder, accompanied with considerable pain. She had suffered in this way for about six months, and had been treated by blisters to the spine, leeches, various liniments, and internally with quinine, calomel, iron, valerian, etc., but without benefit. I was informed that with this exception she was in good health, and I therefore concluded the mischief depended upon some local cause. An examination of the spine showed that there was no lesion in that situation, but upon looking into her mouth a stump and a partially-decayed tooth were seen in the lower jaw on the left side. When I decided to have these extracted she assured me they caused her no inconvenience. Nevertheless, she was induced to have the operation performed, and she got well in a few days."

4. Visceral Disorders.

Neuroses peculiar to the alimentary canal, larynx, heart, and even uterus, arising as a sequence to dental irritation, have from time to time been observed by clinicians. That dental irritation should be reflected to these organs might at first glance seem remarkable, but it is not more so than that mental emotions should result in inhibition of the secretion of gastric juice or that ear lesions should cause laryngeal cough, or that a blow on the abdomen should result in reflex inhibition of the heart. In the instances of visceral neuroses recorded below there can be no question that the reflected current was from any but the medullary centres, but what the exact route or nature of the reflecting process may be it is impossible to state.

Turning to clinical medicine for illustrations of visceral disorders due to reflected irritation from dental nerves, we cannot expect to find a great number awaiting us. If the interrelation of organs so nearly contiguous and directly connected by the same nerve as the mouth and the eye should have been overlooked by clinicians, it is hardly to be expected that disorders of organs more remote and less intimately associated through nervous intermediation should be connected by them with dental pathology. Nevertheless, the fact has been forced upon the attention of some, and a few cases of decided interest and suggestiveness have been recorded. Doubtless, when it becomes more palpable that many disorders, which apparently have no cause for their being, are probably due to reflex irritation, and when the attention of physicians is more especially directed to the pathological conditions of the teeth as giving rise to this irritation, additional instances no less remarkable will be observed and recorded. The following cases will illustrate the connection of visceral disorders with irritation of the dental branches of the trigeminal nerve:

Obstinate Vomiting due to a Deposit of Tartar.—Dr. Masterman reported[2] the following case of obstinate vomiting from irritation of the alveolar and lingual nerves from the deposition of tartar: The patient, a young woman, æt. 22, had always been in good health and only occasionally suffered from dyspepsia. Two months before she was

[1] *Lancet*, 1859, vol. i. p. 80.

[2] *Ibid.*, Sept. 22, 1877.

seen by Dr. M. she began to have "a feeling of constant nausea, which gradually increased to occasional retching, and at length to almost persistent vomiting. The nausea and vomiting went on, and she became rapidly weaker from inability to retain a proper amount of food. One morning she noticed that her tongue was getting sore underneath, and two or three days afterward severe bleeding suddenly occurred: the blood welled up from under the tongue, but was arrested by styptics and a pad." When Dr. M. was called to see her he found her "lying in bed, very pale and weak, pulse rapid and feeble, respiration sighing, temperature normal. The breath was very offensive, but the tongue was clean, and, like the gums, completely blanched. Under the tongue was a small but rather deep ulcer, which had evidently eaten into the ranine artery on the left side and caused the hemorrhage. As I was feeling for some rough point to account for it, the examination being made by candlelight, I at first thought that the girl was wearing a very badly-made lower set of artificial teeth; but a second look showed that what I had mistaken for the vulcanite base was really an extraordinary deposit of tartar blackened by the styptics that had been used, and which half filled up the sulcus between the jaw and the tongue, pushing that organ upward and backward, and accounting alike for the vomiting, the ulceration, and the bleeding. The next morning I easily removed the mass in three pieces with an elevator. It was semilunar in shape, reaching from one first bicuspid to the other, about .4″ in thickness in the centre, and weighed seventy grains. It was quite smooth on the lingual surface, except where it touched the frænum, but very rough and spongy next the gums, which were swollen and bleeding, almost entirely detached from the teeth, and covered with an offensive discharge. There was a considerable deposit of tartar on the labial side of the gums, which I removed at the same time. The nausea ceased immediately, but the teeth were left so loose and the gums so tender that no solid food could be taken for some days. This difficulty was, however, soon got over by the use of local astringents, and the girl was rapidly gaining her strength when typhoid fever set in." The patient recovered and entirely regained her health.

Nausea, Vomiting, Convulsions, and Death from Painful Dentition.—M. Valleix[1] records the case of a young girl of strong constitution and of previous good health. The four molar teeth which complete the second dentition developed themselves simultaneously, giving rise to intense irritation and inflammation at the angle of each jaw. Nausea and irritability of the stomach soon set in, followed by obstinate bilious vomiting. The gums, which covered the teeth, were lanced, without any benefit, however. For several days there was general agitation, strabismus, swelling of the right eye, dilatation of the pupils, followed by convulsions and death.

Intermittent Fever and Gastric Disturbance caused by the Irritation of a Pivoted Tooth.—Dr. Lederer cites[2] the following case: A young lady was sent from Vienna to Horic by her physician in the hope that an obstinate fever of an intermittent type might be benefited by the change

[1] *Clinique des Hôpitaux des Enfans*, Jan., 1846.
[2] *Wiener Medizinische Presse*, June, 1866.

of climate. She was thoroughly equipped with a stock of quinine, and no change of medicine was made. But there was no improvement to be noted, and the patient seemed otherwise in good health. Dr. L. was finally surprised to discover no increase in the size of the spleen, and this led him to doubt the diagnosis. The attacks of fever were of noticeable irregularity, and before long irritation of the vagus appeared as severe pain in the stomach, which only stopped when the stomach had been emptied by vomiting. This was succeeded by diarrhœa, exhaustion, and sleep. It was finally discovered that shortly before the patient's illness began she had had four artificial teeth pivoted in the upper jaw. She was advised to have them removed. This unpleasant announcement lost the doctor his patient, but he subsequently learned of her reinstatement of health, and he believes it was brought about by the removal of the artificial teeth.

Dr. Paasch of Berlin says[1] he has often noticed, even in grown people, that diarrhœa and gastric disturbances have been caused by irritation from bad teeth, etc., he having frequently seen loss of appetite, diarrhœa, and even fever, in those wearing artificial teeth which did not fit well at first or to which they were as yet unaccustomed.

Laryngeal Cough caused by the Eruption of Teeth.—Dr. Paasch records[2] the details of the following case, of which an abstract is here given: A child several months old began to suffer from a hard and painful swelling of the left cheek, which soon broke, and was healed in about a fortnight. On the 9th of April the child became feverish, and the right cheek near the parotid gland became painful without being inflamed. The swelling of the spot continued to increase until it showed fluctuation on the 15th, and was lanced and a large amount of pus extracted. After this there was again improvement until the 1st of June, when the child began to have an unusual flow of saliva and showed signs of trouble in the gums, rubbing them constantly with the fingers. On the 18th the child's voice became hoarse, and soon there occurred a paroxysmal cough, during which the child nearly suffocated. The child would open the mouth widely, throw the head back, and cough as if the larynx were directly attacked. Repeated examinations proved that the pharynx, larynx, and lungs were normal. The cough, yielding to no treatment, gradually became worse. At last two vesicular swellings appeared upon the gum at the spot where the first teeth were to be expected. These became larger and larger, and were of a dark livid color, the cough at this time being very violent and the seizures frequent. On the 5th of August the right lower incisor broke through, and the cough ceased at once. There were slight attacks of coughing until the 8th, when the second vesicle broke and the second tooth appeared. At the end of two days all trouble had entirely ceased.

Aphonia.—Dr. Pointis records in the *Journal des Conn. Med. prat.*, Sept., 1846, the case of a patient who after an attack of toothache "suddenly lost his voice. The aphonia was followed by anorexia, cough, wasting, and feverishness, which lead to the belief that he was suffering from laryngeal phthisis. But the lungs were sound and there was

[1] *Journ. für Kinderkrankh.*, 1856, p. 178. [2] *Ibid.*

no tenderness over the larynx. There was slight inflammation of the pharynx; all the molars in the left under jaw were decayed and the gums and periosteum around them swelled. The teeth were removed, the gums cauterized, and gargles employed. On the very day the teeth were extracted the suffocative spasms which had troubled the patient abated, and on the following days the other symptoms quickly disappeared."[1]

Cardiac Palpitation.—Prof. Remak[2] has called attention to a peculiar form of cardiac neurosis occurring in connection with disease of the last molar teeth of the lower jaw. He cites *in extenso* two cases of severe cardiac distress accompanied with palpitation following toothache. In the first case, that of a young girl of twenty-one years of age, the toothache preceded the setting in of the palpitation of the heart by some weeks, continually growing worse, and finally ending in trismus, great mental distress, and feelings of suffocation. The constant galvanic current reduced the violence of the trismus so much that the tooth could be extracted, after which recovery followed.

The second case was that of a woman twenty-four years of age who had suffered from toothache for several years, being unwilling to have the offending teeth removed. Here likewise trismus was the result, and could not be overcome. For fourteen days the patient had not eaten solid food, having been nourished entirely upon liquids. Great mental anxiety and præcordial distress, fear of death from palpitation of the heart—which was very violent—and marked acceleration of the pulse (140–160 beats per minute) were the chief symptoms. The employment of the constant current finally reduced the heart to normal action and partly broke up the trismus. At a later date the jaw could be depressed enough to examine the mouth. An enormous first molar obliquely placed was wedged in the jaw. Though of excessive size and in an abnormal position, it was neither carious nor sensitive. The patient would not allow its extraction, but Remak attributes the above symptoms to the tooth, and goes on to say that the cases throw light upon the convulsions of teething children, which often threaten life. He says that, though often due to meningitis, the great majority of such cases are caused by difficult dentition, and that neurotic or inflammatory irritation originating in the teeth may induce such a series of reflex paroxysms that life is endangered, and apoplexy may be superinduced by increased cardiac activity with simultaneous spasm of the cerebral vessels.

Dr. Anstie also states[3] that he has known "the operation of pivoting a tooth to give frightful pain and cause instantaneous and most alarming arrest of the heart's action, which for a moment or two seemed as if it were going to be fatal."

Uterine Neuralgia from Dentition.—Mr. R. S. Davis records[4] the following case of uterine neuralgia occurring during the puerperal state: Mrs. S——, a lady of good physique, æt. 25, was delivered of a child. The labor was tedious, being a breech presentation. After the birth of

[1] Dr. Lauder Brunton, *Trans. Odontological Soc. of Great Britain*, 1880.
[2] *Berliner Klinische Wochenschrift*, June, 1865.
[3] *Neuralgia*, 1871.
[4] *Lancet*, August, 1846.

the child the placenta was found to be adherent. There was considerable hemorrhage during its removal. Everything progressed favorably until the sixth day after delivery, when she was attacked with severe pain in the region of the uterus. There was no constitutional disturbance, nor was there any tenderness on pressure over the uterus. Opiates and other sedatives were tried without any benefit. The pain, although of the most severe character, was intermittent, and during the intermissions it was referred to the region of the face, though then so slight as not to attract much attention. The pain, however, continued, and, fearing inflammation, various remedies were resorted to for relief, but without avail. The pain in the face at this time became severe, and led to the supposition that the condition of the teeth might be the cause of the neuralgia in the uterus. Examination of the mouth showed an enlarged and swollen condition of the posterior part of the gum. The mystery was explained. The wisdom tooth was erupting and the irritation was reflected to the uterus. The gums were freely lanced, and from that moment the uterine pain subsided.

Dr. Anstie[1] states that he has seen one case of uterine neuralgia which was clearly proved to have been excited by the presence of a carious tooth, which was itself little if at all painful, but the removal of which at once cured the pelvic pain.

Vicarious Menstruation from Diseased Teeth.—Dr. S. P. Hullihan[2] reports the case of a young lady, æt. 17, who had a fungous growth in each of the second molars of the lower jaw which had assumed a rather novel character. These growths had appeared about four years before, and for the last two years she had been troubled with hemorrhage from them, which took place once a month and continued for several days. Being anxious to save the teeth, the fungous material was removed and the teeth filled. After several days they became sore and painful. The plugs were removed, and a slight bleeding commenced which continued for three or four days, and then entirely disappeared. Again the teeth were filled, and at the end of three weeks they became sore and the fillings had to be removed. Bleeding ensued as before. Suspecting this to be a vicarious menstruation, the teeth were removed. After medical treatment by the family physician she became perfectly well.

(For other instances of the intimate connection between the uterus and teeth see p. 442.)

5. Trophic and Vaso-motor Disorders.

The question of the existence of a trophic centre and a trophic system of nerves controlling the normal metabolism of the tissues has been the subject of much discussion; but, however doubtful the anatomical proof, it may be considered beyond question that physiological and clinical facts necessitate their existence. So far, it has been difficult to differentiate the causes of certain phenomena into those due to vaso-motor and those due to trophic innervation. Woakes[3] gives a number of cases of gunshot injuries of nerves followed by a series of morbid phenomena caused, as he explains, by injuries to the vaso-motor nerves conveyed by

[1] *Neuralgia*, 1871.
[2] *American Journal Dental Science.*
[3] *Giddiness, Deafness, etc.*

the common nervous trunks; and another such a case is the one frequently quoted by writers of an ulceration of the intestine caused by irritation of the skin from a burn.[1] The case cited below of corneal ulcer directly traceable to dental irritation suggests the thought that it is perhaps because of trophic inhibition from the disorders of dentition that so many obstinate cases of keratitis and corneal ulcers exist in children. The corneal tissues, being non-vascular, have to derive their sustenance from the lymph-streams, and may thus be exceptionally dependent upon the trophic nerves and centres. As it has been found that the vaso-motor centre of the medulla, while influencing the vascular system as a whole, is yet a complex of individual centres governing separate and defined areas, so when the trophic centre shall have been anatomically demonstrated it will doubtless be found to correspond to the demands of clinical facts in having foci that likewise regulate limited divisions of the body-surfaces and organs. In this way may be explained various dermal disorders, atrophies, and ulcerations of circumscribed parts and tissues, and such facts as are given below.

Sir Astley Cooper[2] reported the two following cases of ulceration of the skin, in which there was no apparent connection between the diseased tooth and the point of ulceration. They may be regarded very properly as examples of perverted nutrition excited by reflex action:

"A lady was for a long period afflicted with a fungoid granulation which protruded from an ulcerated opening in the cheek: she tried for several months every remedy that was recommended to destroy the fungus, but without producing the desired effect. A tooth nearly opposite the opening being occasionally painful, she was advised to have it extracted: this was done, and there was no longer any difficulty in curing the fungoid growth, for it was absorbed rapidly, the most simple applications being used."

"A gentleman of my acquaintance was much annoyed by an ulcer on the chin, every attempt to heal which had proved abortive. At length one of the neighboring teeth became painful, and was extracted in consequence, when, to the great delight and astonishment of the gentleman, the ulcer on the chin healed rapidly."

Mr. Salter[3] also reports two cases of ulceration and sloughing of the skin caused by morbid conditions of the teeth: "A young woman applied to my relative, Mr. Bell, on account of a remarkable slough of the skin and cellular tissue about the size of a shilling, but of an oval form, just beneath the orbit. It was nearly black and detached from the edges when he first saw it. Mr. Bell removed the slough, but the sore only partially healed, and soon after the same appearances recurred. Upon examining the mouth a diseased stump was found on the same side of the upper jaw, which appeared to be the cause of the irritation. This Mr. Bell removed, the slough separated, the sore healed, and it never recurred."

[1] For full discussions as to the existence of a trophic centre, and for many illustrative cases, see "Injuries of Nerves," by Mitchell, "The Trophic System as a Factor in Pathological Processes," by Bartholow, in *Med. News*, June, 1882; and "Tropho-neuroses," chap. vi. vol. i., Ross's *Diseases of Nervous System;* Landois's *Human Physiology*, Am. ed., pp. 613, 614, and 624.

[2] *Lectures on Surgery*, Am. ed., 1826, p. 9.

[3] *Guy's Hospital Reports*, 1868.

In the second case a small red spot made its appearance without any apparent cause on the right side of the neck behind the angle of the jaw. Ulceration soon set in, which persisted, notwithstanding treatment, for more than a year. By this time the ulcer had attained the size of a shilling. Upon examining the mouth the lower wisdom tooth on the right side was found to be carious. There was no fistulous connection between the tooth, however, and the sore, the latter being quite superficial. After the tooth was extracted the aspect of the ulcer changed, and in a week it had entirely healed.

Furred Tongue on One Side.—Mr. Hilton records[1] having seen a number of instances of a furred condition of the tongue on one side only caused by a carious condition of a tooth on the corresponding side, and regards it as an instance of functional and structural deterioration in the nutrition of the part, depending upon a disturbance of nerve-force. It is a condition frequently associated with diseased conditions of the second and third divisions of the fifth nerve. As soon as the carious teeth were removed in these cases the nutrition returned to its normal condition and the furred appearance of the tongue disappeared.

Ulceration of the Cornea.—Dr. E. C. Wright[2] records the case of a lady, æt. 40, who had an indolent ulcer of a round form on the cornea of the right eye, and had been subjected to violent paroxysms of toothache and neuralgic pains on the right side of her head and face for months. After proper ophthalmological treatment she was advised to consult her dentist, who extracted the upper first molar on the right side, finding an abscess at the root. The same treatment of the eye was continued, and in about three days the eye was well. Dr. W. thinks that the cause of the ulceration in this case was related to the morbid condition of the tooth.

(For the details of a similar case, see Ocular Disorders, p. 455.)

Hip-joint Disease.—That the eruption of the teeth and the development of disease of the hip-joint should in any way be associated as cause and effect may at first sight appear highly improbable. Yet such a relation has been asserted by competent surgeons and denied by others. It has been frequently noticed that in a scrofulous constitution disease of the hip-joint most often makes its appearance at the period of the eruption of the first four molar teeth; that is, from the fifth to the seventh year. The continual irritation of the fifth nerve caused by their eruption, being reflected to the nerve-centres controlling the nutrition of the joint, is supposed to modify their influence, and in susceptible subjects to result in the production of this unfortunate pathological condition. Mr. Hilton,[3] commenting upon dentition as a factor in the production of hip disease, says: "It must be of comparatively rare occurrence, for it certainly has not fallen to my lot to see more than one or two cases which could give any legitimate support to such an interpretation."

Since Mr. Hilton's lectures were delivered, Dr. Joseph Mulreany of New York has written a paper[4] upon the "Constitutional Relations of the Second Dentition," in which he calls attention again to the fact that

[1] *Rest and Pain*, Am. ed., pp. 116, 118.
[2] *Indiana Medical Journal*, July, 1872.
[3] *Op. cit.*, p. 198.
[4] *New York Med. Journ.*, Jan., 1874.

in scrofulous children hip disease makes its appearance during the eruption of the molar teeth, and often passes away after they have pierced the gum. He gives it as his opinion that dental irritation was the direct exciting cause in the following cases:

CASE I.—"Miss W—— (aged now about twenty-six years) when a child of between five and six years was a patient of mine for morbus coxarius. The first indications of the joint disease were lameness and pain when the head of the femur was strongly pressed against the acetabulum. In process of time the usual symptoms of pain in the knee, flattening of the hips, and shortening of the limb took place, but all in a mild and modified form. All these symptoms at the end of her sixth year subsided coincident with the complete protrusion of her first four molar teeth, leaving her slightly lame for life. She can at present dance and exercise as well as most young ladies. She is a member of a family of a highly scrofulous diathesis."

CASE II.—M. C——, æt. $6\frac{1}{2}$ years. This child had pain in the left hip-joint and knee of the same side for over a year, during which time she had been rather lame. For several weeks before she visited Dr. M. she had suffered rather more and walked with a greater halt. There were, in addition to her lameness and pain, flattened hip, changed rotundity of the gluteal muscles, appreciable shortening of the leg, and arched instep. The first three molar teeth were through, the right upper to come. The gums were scarified and the patient given iodide of iron. In six weeks the child had very materially improved.

Cutaneous Affections.—Dr. Hamilton Cartwright[1] read a paper before the Association of Surgeons practising Dentistry, upon teething and its complications. In the course of his remarks he alluded to the frequent occurrence of skin diseases during dentition, and gave it as his opinion that there was probably more than a chance connection between them, owing to the fact that the teeth were developed out of dermal structures. In the discussion that followed Dr. Little mentioned the case of a lady who when cutting her wisdom teeth was attacked by a severe impetiginous eruption covering her head, ears, and face.

Traumatic Herpes of Dental Origin.—At a meeting of the French Academy of Medicine, M. David reported three cases of herpes occurring upon the cheek and gums, two of which were caused by operations upon the teeth, while the third was caused by the irritation excited by an erupting wisdom tooth. An abstract of his paper is given by M. Josias:[2] "The author proceeded to notice the extremely slight injury which in two of the cases produced the eruption. The pathogeny of this affection, whose history is not completely known, is of importance. In two of the cases a general malaise was experienced before the appearance of the herpes; there were also marked febrile indications, which clearly showed the general character of the affection. In two cases at least, then, M. David rejects the theory put forward by M. Verneuil—viz. the calling into existence of a constitutional influence; he saw, in other words, only a simple case of febrile herpes. In the third case the eruption occurred several times upon the gums after inflammation of a portion of the mucous membrane above

[1] *British Med. Journal*, 1877.

[2] *Le Progrès médical*, 1879, p. 731.

the wisdom teeth, the inflammation being produced during the cutting of these teeth; that is to say, it was due to a particular complication caused by the cutting of the wisdom teeth. The observation is interesting, as it explains to a certain extent the nature of the aphthæ, which some authors, apparently with reason, have called herpes of the mucous membrane. The conclusions which have been arrived at in regard to this subject are—(1) Some of the vesicular eruptions of traumatic origin may be regarded as the result and critical sign of the fever which precedes their appearance: this may be allowed, while the initial cause is understood to be the wound itself. (2) A herpetic fever, as stated by M. Parrot, actually exists. (3) Wounds and the various operations performed upon the teeth, and in the mouth generally, may be considered sufficient to produce herpetic fever or herpes in the usual sense of the word."[1]

B. Affections of Nerves and Subordinate Nerve-centres.

1. Facial and Other Neuralgias.

It seems to have been thoroughly established by the recorded observations of clinicians that dental irritation may give rise to neuralgia in many nerves, and more particularly in the branches of the trigeminal nerve itself. The peripheral irritation in such instances, after being reflected to the nerve-centres, instead of passing over to adjoining motor centres, induces some pathological condition of the nervous structures themselves, which manifests itself as pain. Whatever the pathology of facial neuralgia may be, it seems unquestionable that the disease may be caused by a dental irritation, and in such instances often cannot be distinguished from a neuralgia induced by any other cause.

Neucourt[2] early emphasized the part played by the teeth in the excitation of neuralgia, and sought to lay down rules for diagnosticating a neuralgia of dental origin. These, in brief, were as follows:

1. When a tooth is in itself the seat of pain and the patient definitely specifies it as such, there can be no doubt that it is the origin of the disorder.

2. When, in addition to the pain, there follows a swelling of the cheek or gum resulting in abscess, the indication is specific; if a tooth is sensitive to percussion and seems longer than others, the indication is decisive, whether it be carious or not.

3. Even if the pain is diffused and spread over the side of the face, and attended with distinct exacerbations, thus presenting all the signs of typical facial neuralgia, nevertheless, if it eventually localizes and limits itself in the region of the dental arch, accompanied with pain, redness, swelling, and extreme sensibility to pressure, possibly terminating in an abscess, the disturbance is in such cases of dental origin. I have never seen an exception to this rule.

4. Another point serving to distinguish neuralgia of dental origin from that due to other causes is the continual agitation and persistence of discomfort of the patient. There are no such periods of calm as

[1] *Cincinnati Lancet and Clinic.* [2] *Archives générales,* Juin, 1849; Oct. to Dec., 1853.

occur in neuralgia from other causes. The pulse is accelerated and hard, and there is at times general sweating.

In the different papers of Neucourt seventeen cases of neuralgia of dental origin, illustrating the above points, are detailed.

The puncta dolorosa, or painful points, of Valleix are a common symptom of "true" neuralgia, but are by no means invariably present or pathognomonic, for, as Neucourt showed, they may be present in neuralgia of purely dental origin. The same may be observed of the *point apophysaire*, or spinal point, of Trousseau.

As will be seen from the appended illustrative cases, there is a general tendency for the neuralgia of dental origin to manifest itself in the face, but this is by no means an invariable rule. Cervico-brachial neuralgia, as pointed out by Mr. Salter,[1] is a very frequent form of neuralgic trouble dependent upon the presence of carious teeth. Indeed, it is so common that Mr. Anstie[2] assumes that there exists a peculiar disposition or organization of the spinal centres of these nerves to account for the fact. Even sciatica and visceral neuralgias may be so caused. The following cases are of a typical and striking character:

Friedberg has reported[3] in detail the four following cases, abstracts of which are here given:

One-sided Facial Neuralgia of Five Years' Duration cured Immediately by Extraction of Two Carious Teeth.—Dorothea K——, æt. 37, a working-woman, began to be troubled by pains accompanied by swellings in the finger-joints. She thought these came from washing clothes in cold water. These pains sometimes extended up the arms, even to the shoulders. She endured these pains for two or three years, when there were also superadded oft-repeated attacks of neuralgia in the left side of the face, lasting several weeks, when the pain changed its seat and character. Pricking, burning, darting pains then shot from beneath the left ear through the cheek and temple, sometimes from these parts toward the ear. Especially racking was the suffering when the eye and forehead were the seeming seat of the assault. The patient was sometimes unable to open the eye from blepharospasm. The middle line of the face was never passed. The patient did not know if the teeth ever ached at the same time, but was emphatic that the beginnings of the attacks were as given above. The duration of the seizures was variable, they sometimes lasting only for a few moments, and sometimes for an hour. The time of freedom from attack was also variable, ranging from a few hours to a couple of weeks. In May, 1859, the menses ceased, and from that time the exacerbations became more severe and more frequent. In August the patient presented herself at the clinic of Dr. Friedberg. The fingers and some other joints seemed to be suffering from arthritis, though movements of the fingers were fairly good and painless. The cuspid tooth and third molar of the left upper jaw were in bad condition, though both were insensitive to percussion. The next day after their extraction the patient returned with great joy to report the first night's rest and sleep she had had for a long time. There were occasional flitting twinges for a few days, but the cure was immediate and perfect. The

[1] *Guy's Hospital Reports*, 1868.
[2] *Neuralgia.*
[3] *Virchow's Archiv*, Band xviii.

remarkable fact was subsequently learned that there was a resumption of the menstrual function fourteen days after the cessation of the neuralgia.

Facial Neuralgia of One Year's Duration cured by Extraction of a Carious Tooth.—The patient was a man, æt. 32, in good health. He first experienced flitting pains about the head in consequence of a severe cold. These, under house treatment, were succeeded by pains about the cheeks, sometimes in the upper, again in the lower jaw and upon either side of the face. There was then a space of a few weeks of relief, when lancinating pains were again felt in the right cheek, shooting about the face from the eyes to the lower jaw; then periods of relief and returning attacks followed each other, the eyes, forehead, and side of the head gradually becoming implicated. When the eye was attacked conjunctivitis and epiphora followed. In the severer assaults the eyelids, lips, and even the muscles of the face, were seized with spasmodic twitchings. Toothache, properly speaking, he had not, the pains often shooting toward rather than from the teeth. The patient himself had had two carious teeth extracted in the hope of relief, but in vain. After about eleven months' continuous suffering, upon the advice of a surgeon another tooth was extracted, though it only showed a slight carious imperfection and the patient had never suspected any trouble from it. It proved to have attached to its roots a fungoid growth. The pain at once stopped, and after four days, during which there was slight numbness in the face, the patient had no recurrence of any trouble.

Neuralgia of Six Months' Duration.—Emma S——, æt. 31, was suddenly seized with severe neuralgic pains, sometimes upon the right, sometimes upon the left side of the head. These were at times associated with aching of the teeth or jaws, but settling upon no one spot. She had several carious teeth extracted without getting any relief. The eyes, forehead, temples, and the left ear became implicated. Everything was done medicinally without any benefit. Finally, her memory began to fail and her general health gave way. In spite of the patient's protest that she had never had toothache, a tooth was extracted, though only but little decayed and showing no sensitiveness to percussion. It was found to have upon the fang a mass of inflammatory and purulent matter. From that hour there was no recurrence of the neuralgia.

Another case, almost exactly parallel to the above, of severe facial neuralgia in a woman of forty-five, is reported in the same article. The pains began in the right temple, extended to the eye and half of the head, accompanied with blepharospasm and epiphora; finally, the right side of the nose, cheek, and the upper part of the neck became involved. The patient had early tried the experiment of extraction of a carious molar tooth. After suffering five months, other fangs and decayed teeth were extracted, somewhat against the patient's will, resulting, however, in an immediate and perfect relief from the neuralgia.

Facial Neuralgia from Nodular Dentine, related to the writer by Dr. Alfred Gysi.—Miss L——, æt. 30, general health good. For several weeks had been suffering with severe and excruciating neuralgia in the upper maxilla of the right side, which radiated at intervals all over her face, and which she attributed to several carious teeth. Their removal,

however, did not bring about any change in her condition, the pain continuing as severe as before. As nearly all of her teeth had been extracted, and the right central incisor was quite isolated, she desired to have it taken out in order to be able to wear an artificial denture. Though this tooth showed no signs of decay or of exostosis, its extraction was at once followed by complete relief from the pain. A microscopical examination of the tooth showed the presence of six nodules of secondary dentine projecting from the wall of the root portion of the pulp-chamber, diminishing very markedly its calibre and compressing the terminal filaments of the nerve.

Facial Neuralgia from Carious Wisdom Tooth.—Dr. Castle[1] relates the following case: A lady for some days had been suffering the greatest tortures from neuralgic affections in the right eyeball, supra-orbital nerve, and in the temple round to the occipital portion of the head; the pain also extended from the superior cervical vertebræ down under the deltoid muscle into the axilla, and along the terminal branches of the brachial plexus; also along the ramus of the jaw to the tongue, with constant twitches of the platysma myoides and partial paralysis of the palpebræ superioris. From the fact that the ramus of the jaw was affected, and that there was a tenderness in the inferior cuspid tooth, it was thought possible that the neuralgia might arise from a decayed dens sapientiæ. Upon being called to see the patient, the doctor found her in bed: she was feverish and pale; her pulse quick and hard; her breathing short; her countenance anxious and expressive of much suffering; she had violent throbbings at the temples, which the neuralgic paroxysms increased, and was disturbed by light. He found a diseased tooth, and at once extracted it. After several hours' sleep she rose from her bed, and she has had no return of her affliction since, upward of five years.

Facial Neuralgia from Ulceration of the Gums.—The three following cases have been reported by Dr. J. Ferrier:[2]

Dr. C——, æt. 28, has been suffering for eight days with a severe and continuous neuralgia in the inferior maxilla at a point corresponding to the root of the right inferior first molar. From this point the pain extended, from the time of its appearance to the moment of its greatest intensity, backward into the right ear. The inferior first molar of the right side had been extracted three years before, but the extremity of the fractured root had been left in the alveolus. This root had gradually been brought into contact with the gum, which had almost enclosed it, and excited there an ulceration which became painful during mastication. The gum was destroyed with the electro-cautery and the root removed; since then there has been no return of the pain.

Facial Neuralgia from Periosteal Cyst.—M——, æt. 35, presented herself on the 28th of February suffering with double conjunctivitis and neuralgia. Two months before the patient noticed a small tumor at a point corresponding to the root of the left superior second molar. This tumor attained the size of a walnut without causing any pain. For some days, however, the conjunctivitis has been getting worse and

[1] *London Lancet*, 1846, p. 266.

[2] *Les Névralgies reflexes d'Origine dentaire*, 1884. In this paper will be found an admirable account of the relationship of morbid conditions of the teeth to facial neuralgia.

was attended with circumorbital neuralgia and photophobia. Two weeks later the pain and conjunctivitis became intense, extending all over the circumorbital region. Incision of the cyst with the thermo-cautery and a resection of a portion of the osseous wall gave the patient instantly great relief. The photophobia disappeared at once. The cyst contained a yellow fluid loaded with crystals of cholesterin. A week later the neuralgia had entirely disappeared, the conjunctivitis had diminished, and there remained only a slight tenderness to pressure at the infraorbital foramen.

Facial Neuralgia.—M. F——, æt. 43, had been suffering for three years with neuralgia, which appeared simultaneously with an alveolar periostitis which has caused her to lose the superior right first and second molars, the second premolar, and the superior left first molar. The neuralgia occupied the orbital region. At times it became more severe and extended into the occipital region and down into the neck. The pain was more frequent on the left than on the right side. On the former side the sight was excellent, but the hearing was impaired to such an extent that the patient could not hear the tick of a watch applied to the ear. The ear was also the seat of sounds analogous to those produced by vapor escaping from a locomotive. During the three months before the case was reported some decayed teeth had fallen out and the pain had become much better. At the time of the report it was confined to the orbital region and to the upper cervical vertebræ. The patient refused to have the remaining decayed teeth removed.

Neuralgia from Exostosis.—Dr. Robert Robson[1] relates the following interesting case of excruciating neuralgia dependent upon the presence of ossific deposits around the roots of a number of teeth: "Was called to see Mrs. H——, and found her suffering the most excruciating pains in the face, the side of the head and neck, these being at all times attended with a constant grumbling, though acutely paroxysmal in its general character. There was no fever, tumefaction, or heat; it was a clear case of neuralgia, from which she had not been free for many months; indeed, such was her suffering that she seemed on the verge of the grave. She told me that the doctors had done all that could be done for her, she believed. She had been bled, blistered, and had taken medicine for months without any permanent relief. Under such circumstances I strongly suspected local irritation of the nerves or disease of the alveolus, and carefully examined her teeth and extracted every one very much decayed. While doing so I accidentally tapped with the forceps those immediately adjacent, which caused the most intense suffering to the patient. The tooth extracted was connected at the fang with an exostosis as large as a small pea. I then advised, and with her consent extracted six more, all of which were analogous to the first, having more or less osseous deposit in the fang; after which she was much relieved, and after the use of gentle stimulants and tonics she gained strength and became comparatively well, and died about three years afterward."

Neuralgia with Deafness from Painful Wisdom Tooth.—M. Ed. Vau-

[1] *Georgia Medical Companion*, 1872.

tier[1] records the following case: "The subject of the neuralgia was a very slender, nervous woman, who had suffered for about four months with intense neuralgic pains radiating through almost all her teeth, and also through the muscles of the anterior region of the left side of the head. There was constant lachrymation of the left eye, and from the moment of the attack complete deafness in the ear of the same side. A number of physicians had been consulted, and quinine, atropia, blisters, in succession tried without giving relief. When Dr. B—— was called to see her she had been long deprived of sleep and could not chew her food. The teeth were examined with care, but none could be found carious. The wisdom tooth on the left side seemed, however, slightly painful on being touched and loose: she was advised to have this tooth extracted, but with some temper refused. However, some days after, her physician again advising it, she consented, and the tooth was extracted. The pain at once ceased and her hearing was restored."[2]

Neuralgia from Fragment of Root in Alveolus.[3]—"Miss L——, æt. 40. For two years the patient had suffered with the most severe attacks of neuralgia, involving the superior and inferior maxillary branches of the trifacial nerve. The pain had become so constant and severe that her general health had become materially affected. She had become considerably emaciated and prostrated from the pain, loss of sleep, inability to eat, etc. The most constant medication at the hands of skilful physicians had failed to give her relief. I was requested to examine her mouth for a local source of irritation. There was an absence of the inferior first molar of the left side, which had been extracted some years before, and the gum had healed perfectly and was apparently in a normal condition. Opposite the first bicuspid tooth, however, there was a small pin-point opening into which a small probe could be passed some distance, when it came in contact with a rough surface which it was supposed was a portion of the root of the tooth extracted years before. Upon laying open the jaw the root-fragment was found, and in an exostosed condition. After removing it the neuralgia disappeared, and the patient was gradually, though completely, restored to health."

Neuralgia from Osteo-dentine.—Dr. A. Miller[4] reports four cases of neuralgia due to the presence of granules of osteo-dentine in the pulp-chamber; one of the most interesting is the following: "Mrs. R——, æt. 30, who had suffered more or less at intervals for about a year, was treated by a physician for idiopathic neuralgia without any benefit, he being unable to discover any cause. The pain was confined to the left side of the face and head, with occasional darting pain in the neck, shoulder, and arm. I examined all the teeth on the left side carefully, also on right side. Many of the teeth contained small cavities, but the pulps were not exposed. I tapped each tooth with an instrument, and the patient experienced, as she said, a 'curious' feeling in the left superior second molar. With a small drill I entered through the cavity of decay into the pulp-chamber; the patient experienced but little pain. I

[1] *Gazette des Hôpitaux*, June, 1860.
[2] *American Journal Medical Sciences*, October, 1860.
[3] Related to the writer by Dr. C. N. Pierce.
[4] *Dental Register*, 1874.

enlarged the opening, and with a fine-pointed instrument made an examination and discovered a bundle of semi-bone-like material in the pulp-cavity. I removed it, and the patient has not had a symptom of pain since, now over two months ago."

Neuralgia of the Arm from Carious Teeth and from Undue Pressure of Artificial Teeth.—Mr. Salter[1] records the following case of a lady who had been under his care for many years; she had lost all her teeth and was then wearing an artificial set: "One curious fact was constantly observed during the progress of her case. When any one of the teeth in the lower jaw on the left side became irritable or tender from caries, she was immediately attacked with severe neuralgic pain at a spot, small and circumscribed, on the front of the left forearm, about two inches below the line of flexion of the elbow-joint; and, what is more remarkable, is, that when her artificial teeth hurt the lower jaw on that side, the same symptom manifested itself. The right side has never been similarly affected."

Neuralgia of Face, Neck, and Arm, with Partial Paralysis of the Latter, from Carious Wisdom Tooth.[2]—Miss W—— applied to Dr. Wilks for relief from a constant aching pain on the left side of the face and neck and left arm. The pain sometimes became intensely severe. The arm had nearly lost all muscular power; the patient could not raise it to her head or squeeze any object in her hand. This state of things had existed for two years, and the patient had been under medical treatment all the time. Upon examining her mouth Dr. Wilks observed that the left inferior dens sapientiæ was carious. He sent the patient to me, and I extracted the tooth. She immediately felt great relief, and in a few hours all the symptoms had completely disappeared."

Sciatica.—Dr. Castle[3] reported the case of an oculist who was troubled with sciatic pains along the course of the nerve which were severe enough to cause great inconvenience and considerable lameness. The pain shooting along the nerve caused violent twitchings in the calf muscles. The patient attributed the pain to a severe cold; had tried various remedies for relief; several months, however, had elapsed and the pain and lameness had increased rather than decreased. Upon shaking hands rather violently one day with a friend, he was seized with a severe pain in the shoulder and neck, spasmodic twitching of the muscles of the face, and pain in the anterior bicuspid tooth. Upon examination the wisdom tooth was found to be carious and the pulp exposed. After its extraction the patient paced the room for some time in conversation, and suddenly exclaimed that the pains and lameness had entirely disappeared. He has never had a return of the sciatica since.

At a meeting of the Association of Surgeons practising Dental Surgery, Feb. 18, 1880, a number of interesting cases were reported connected with dental pathology.[4] Mr. Edgelow narrated a case that came under his notice at St. George's Hospital in which exostosis of the root of a tooth had caused severe pain in the hand, which at once sub-

[1] *Dental Pathology and Surgery.*
[2] *Ibid.*
[3] *Lancet*, vol. ii., 1846, p. 266.
[4] *Ibid.*, May, 1880.

sided on the extraction of the tooth. Mr. Ranger also stated that in two cases which he had recently met with the same result had followed. The first was that of a young man who suffered extreme pain in the right arm and down to the hip-joint. He found a lower bicuspid very much decayed, and on destroying the pulp with arsenic the pain ceased almost immediately. The other case was that of hysteria in a girl; in this instance, on the removal of a lower bicuspid much decayed, the symptoms at once subsided.

Many other interesting and remarkable cases of facial neuralgia incited by dental lesions will be found in the papers of Dr. Truman, *Dental Cosmos*, Aug., 1874; Sewill, *Harveian Soc. Rep., Brit. Med. Journal*, 1875; Winterbottom, *London Specialist*, 1881; Mummery, *Med. Times and Gazette*, 1880; Cartwright, *Brit. Med. Journal*, 1876.

2. Paralyses and Pareses.

Reflex paralysis has frequently been observed as the result of diseases of the alimentary canal and urinary organs. That similar reflex paralyses involving the face, arms, and legs may be induced by dental irritation would seem to be placed beyond doubt by the following remarkable cases. The proof that in these instances of facial paralysis, monoplegia, hemiplegia, and paraplegia the exciting cause resided in lesions of the dental nerves is shown by the fact that after the removal of the supposed cause the paralysis gradually passed away and the muscles resumed their normal action. It is of course impossible to state why or how the neural irritation after being reflected to the trigeminal centre inhibits the activity of both the medullary and spinal motor centres. Whatever the true pathology may be, there is a cessation in the discharge of efferent impulses through motor nerves, so that the motility of the corresponding muscles is temporarily impaired. The central trouble is most probably functional in character and not connected with foci of inflammatory action. It is to be much regretted that there is no statement as to the electrical reaction of the muscles in the following cases.

As reflex paralyses from all causes are limited in number, it might be expected that cases directly due to dental lesions would be comparatively infrequent; but it is certain that they exist, and that they deserve a more careful consideration at the hands of the dentist and physician.

The most common form of paralysis of dental origin is that involving the facial nerve and its muscular distribution, as shown by the appended cases:

Facial Paralysis from Carious Tooth.[1]—"The case was that of an overseer, æt. 39, who suddenly, while inspecting cloth, was attacked with facial paralysis, supposed to be due to a carious bicuspid in the lower jaw of the paralyzed side. The tooth had been filled with amalgam about a month previously, and it gave him so much pain that he went back with the intention of having it extracted: to this the dentist objected, and drilled a hole in the side of it and destroyed the pulp. After this the tooth gave him more or less uneasiness until about a month before the occurrence of the facial palsy. The tooth was at once extracted, and found to have undergone partial absorption at the root;

[1] John H. Gillman, *Boston Med. and Surg. Journal*, 1867.

it emitted a most offensive odor. After about three weeks of medication and the use of electricity the patient completely recovered full use of the paralyzed parts."

Facial Paralysis caused by the Evolution of a Second Molar.—Dr. F. Evarts[1] reported the following case of facial paralysis at a meeting of the State Medical Society of New York: "A lad fourteen years of age was attacked with facial palsy, which was probably dependent upon the irritation caused by the evolution of the second molar tooth of the upper jaw. It disappeared after free lancing of the jaws, the use of mild cathartics to keep the bowels soluble, frictions to the face with equal parts of soap liniment and tincture of capsicum, and the application of galvanism."

Facial Paralysis from Carious Teeth.—Dr. Coale[2] reported the following case to the Boston Society for Medical Improvement: "The patient was a girl, aged eighteen, who at first noticed that her face was somewhat stiff, and in twenty-four hours completely paralyzed on the left side. There was great distortion on laughing or talking, a staring of the left eye, and tenderness on the whole left side of the face. The tongue was not at all affected, the disease being confined to the portio dura. No cause could be found for it, unless it were that she had defective teeth in each jaw—as many, however, on one side of her mouth as the other. All remedies failed to give her relief. After the lapse of three weeks she was advised to have her carious teeth removed, and thirteen were accordingly extracted. This was followed by manifest improvement in the course of five days. Electro-galvanism was then gently employed, and the patient entirely recovered."

(For other interesting cases dependent upon similar lesions see Salter,[3] Bacon,[4] McQuillen,[5] Nairne.[6])

Paralysis of the Arm from Dental Irritation.—Dr. Whitney related the following case of partial paralysis of the arm consequent upon caries of the wisdom tooth, before the Buffalo Medical Association, and was reported by Dr. Peters:[7] "The patient was a thin, spare woman, about forty years of age, of decided nervous temperament. She had had very little pain in the tooth, but for several weeks or months considerable pain in the right side of the neck, extending to the shoulder and arm, with rigidity of the muscles and at times immobility of the arm. On raising the hand to the face to locate the pain, it fell to her side. On coming in contact with the nerve in probing the tooth, the effect was more manifest in the arm than in the tooth by painful twitching of the muscles, with an inability to raise it—so much so that she took hold of it with the other hand. He (Dr. W.) was now fully satisfied that the trouble in the arm, that had nearly deprived her of the use of the needle and had given her so much anxiety, and had been treated with fomentations, lotions, frictions, etc., was referable to the condition of the pulp by reflex action. The usual mode of devitalizing and removing the

[1] *American Journal of Med. Sciences*, Oct., 1860.
[2] *Boston Med. and Surg. Journal*, Aug., 1862, p. 14.
[3] *Dental Pathology and Surgery*, p. 270.
[4] "Proc. New York State Med. Soc.," *Amer. Journal Med. Sci.*, Oct., 1859, p. 493.
[5] *Dental Cosmos*, Sept., 1871.
[6] *British Medical Journal*, 1878.
[7] *Buffalo Medical and Surgical Journal*, 1865.

pulp and filling the cavity entirely cured the other annoyances at once."

Paralysis of the Arm from an Impacted and Carious Wisdom Tooth.—Dr. Salter[1] relates a similar case. The patient, a young lady æt. 24, consulted him for relief from a painful condition of the left wisdom tooth. The tooth had erupted, but was not much above the gum-margin; it was impacted, and quite carious. "Latterly, the pain had been intense, and for a fortnight there had been paralysis of the left arm: the patient complained of total inability to use the arm, to raise it, or to grasp with the hand; she could not employ the limb in dressing herself, and could not hold her fork at dinner. There was also a continuous pain of the whole arm resembling rheumatism. I extracted the tooth, but with extreme difficulty. As soon as the patient recovered from the pain of the operation she declared that the arm symptoms had vanished completely."

Hemiplegia and Spinal Irritation caused by Defective Teeth.—Dr. J. L. Suesserott[2] reports the following case: Mrs. H——, the mother of two children, was suddenly seized, without any premonition, with hemiplegia of the right side. There was no unconsciousness nor any acute pain anywhere. Upon examination Dr. S. found the spine tender to the touch. The bowels were constipated. Counter-irritation was established all along the spine by the application of cantharidal collodion, and the bowels regulated with a purgative. She was then placed on tonics; active frictions were directed to be made to the side. After the lapse of a week it was found that sensation was returning, and that the spasms that were excited in the spinal muscles by pressure were weaker and less frequent. An examination of the mouth showed a number of decayed teeth and dead roots in the upper jaw. It was then decided to extract them as soon as possible. In a few weeks she was sufficiently strong to bear the pain of the operation. The patient refused to take any anæsthetic, and as each tooth was drawn she exclaimed that a thick cord was being drawn from her spinal marrow. After all her decayed teeth were extracted a subsidence of all her symptoms rapidly ensued. The pain and spasms, leaving the region of the spine, were for a short time transferred to the muscles of the throat, but in the course of a few months she was entirely restored to health.

Hemiplegia from Carious Tooth.—Sir Astley Cooper[3] relates the case of a lady under the care of Mr. Toulmin who appeared to be afflicted with hemiplegia; at the same time she was suffering severely from a diseased tooth. Mr. Toulmin extracted the tooth at the lady's desire, and in a short time the paralytic trouble entirely disappeared.

Paraplegia from Unerupted Wisdom Tooth.—Mr. Corbett[4] states that Dr. R——, a patient of his, related the following account of his daughter: "Nothing unusual was observed in her condition since birth until within a period of two years, when weakness of the lower extremities showed itself, accompanied with occasional impairment of vision. This state of things gradually grew worse until the power of

[1] *Guy's Hospital Reports*, 1868.
[2] *Dental Cosmos*, Nov., 1868.
[3] *Lectures on Surgery*, Am. ed., 1826, p. 9.
[4] *Transactions of International Medical Congress*, 1881, p. 476.

progression was quite gone unless assisted. There was complete loss of vision when she assumed the erect from the sitting posture, though in the latter she could see distinctly large objects." As no apparent improvement could be observed in her condition, although all forms of medication had been tried, Mr. Corbett requested the privilege of examining her mouth, which was granted. He found "the dental arch in the lower jaw complete as to number, the dentes sapientiæ only partially erupted, the circumference and superior aspect fully exposed, but still giving unmistakable evidence of severe pressure against the second molar to the extent of slight lateral displacement outward. I extracted the second molar tooth on each side: within a week a slight improvement was observed, which gradually increased until three months had passed, when every iota of constitutional disturbance save one had disappeared: the power of vision in the right eye was lost, but she is now in the enjoyment of the most perfect and robust health."

General Paralysis from Carious Wisdom Tooth.—Mr. J. L. Levison[1] records this remarkable case: "A young lady was brought to my residence to have her mouth examined. On being removed she was supported by a lady on one side and a man-servant on the other, and her entire muscular system seemed paralyzed. Her legs trailed upon the ground like useless appendages; her arms, when raised, fell powerless immediately when unsupported; and even the muscles of her tongue were paralyzed, and in her efforts to speak this important organ remained in a quiescent state. On examining her mouth I perceived a dens sapientiæ of the lower jaw very carious and deeply imbedded in the temporal muscle just below the ridge of the coronoid process, in which locality there was extensive inflammation. I suggested the removal of the latter tooth, and, though I anticipated some advantage from the operation, the actual results astonished me. She instantly obtained the free motion of her tongue, which she immediately used to communicate an important fact—viz. that ever since the time the tooth I had extracted had been making its way through the gums she could date the gradual loss of power over her limbs, etc. I saw her about a month afterward: she could then use her arm and hand; she was writing a letter. Since then I have not learned what further progress she has made."

Infantile Paralysis.—Whether infantile spinal paralysis, attended with atrophy of the multipolar cells of the anterior horns of the gray matter, is ever the result of lesions of the dental nerves is exceedingly uncertain. Inasmuch as the disease so frequently occurs during the first three years of life, most writers upon this subject admit that the disorders of dentition are potent factors in the production of the disease. The matter, however, is vague and uncertain, and but few cases have been recorded where the results showed a causal relation between the dental irritation and the appearance of the paralysis.

The temporary forms of infantile paralysis have, however, been more frequently attributed to dentition than those permanent forms in which there is usually a partial destruction of the spinal motor centres.

Dr. Kennedy[2] of Ireland was one of the earliest observers to call

[1] *London Lancet*, 1851.

[2] *Dublin Medical Journal*, vol. ix.

attention to the relations existing between the temporary forms of infantile paralysis and dentition. He publishes the details of a number of cases of paralysis in the young, and says: "The cause of this affection would appear to be usually some irritation in the bowels or else that arising from dentition."

Dr. Fliess[1] more accurately states the question, and ascribes these paralyses directly to dentition: "When a child during the first or second dentition is suddenly seized with paralysis of one arm or of the whole side of the body, or is affected in only a part of the same, without any obvious external cause, this is to be considered as a paralysis from dentition. An accurate examination of the mouth will confirm the diagnosis, for the teeth will be found firmly compressed within the gums. Generally the molar teeth are at fault, much more seldom the incisors, etc. etc." The report of a case is given in full of a boy aged five years who awoke after a night's sleep, during which there had been great restlessness, feverishness, flushed cheeks, and grinding of the teeth, with the left arm completely paralyzed. It was discovered that "the anterior milk molars were lying half decayed in the gums, and near them were the edges of the permanent molars in a row." It was immediately resolved to have all the decayed teeth extracted, to see if any improvement in the child's condition would ensue. The child, however, was killed the same day by accidentally falling from a wagon on his head. A post-mortem examination showed, apart from the fracture of the skull, great venous congestion extending from the spinal roots of the brachial nerves on the left side to the shoulder, neck, and face. "There appeared to be no doubt that dentition had produced this state of the veins."

Dr. Brown-Séquard,[2] lecturing upon the paralyses of the lower extremities dependent upon sympathetic irritation, thus speaks of those cases of paraplegia due to teething: "I have seen a very interesting case of this kind in which the paralysis which appeared at the very beginning of the second dentition in a boy five years old increased and decreased alternately at the time of and after the cutting of each of three molars. In that case there was a slight contraction in some of the paralyzed muscles. Simple hygienic means, shampooing, galvanism, etc., were employed with success. Underwood has seen a case of paraplegia appearing after every cutting of a tooth. Fliess and others have shown the relation between teething and paraplegia, and it would not be difficult to prove that those very able writers—especially Dr. Kennedy and Dr. West—who think that it is chiefly the condition of the bowels in teething that causes the paralysis, have been misled by the fact that very frequently enteritis precedes paralysis. Usually, enteritis in teething, as well shown by Dr. Cain and Dr. Fraser Campbell, is produced by a reflex action, and paralysis seems to be generated in the same way."

3. TETANUS.

Tetanus is an acute motor spinal neurosis characterized by muscular contractions, which are more or less continuous, though attended with

[1] *Journal für Kinderkrank.*, 1849. [2] *Lancet*, Feb. 28, 1860.

distinct exacerbations, and due to an abnormal excitability of the motor functions of the spinal cord and an increase in reflex activity.

The disease may be idiopathic or traumatic. The latter embraces all varieties of injuries and wounds, diseases of the uterus, and parturition; and it must not be forgotten that the severity of the disease bears no relation to the character or violence of the injury. The exciting cause may be so slight that it may be forgotten before the tetanic symptoms make their appearance.

That this state of increased spinal excitability can be produced by injuries to dental nerves, and that they should be considered as possible causative agents in the production of tetanus, will be made apparent by the following cases:

Tetanus from Pivoting of Tooth.—Mr. John Tomes[1] records the following case of tetanus induced by the irritation of a newly-exposed pulp by a gold peg which "pivoted" an artificial tooth upon a tooth-fang: "The following statement was placed in my hands by a medical man who had some knowledge of the case which is related: —— ——, Esq., æt. 25, tall and thin, but apparently in very good health. On his marriage-trip he visited Paris, and there had the misfortune to break off a front tooth. Wishing to conceal the accident from his wife, he went immediately to a dentist. The tooth was pivoted (and I have no doubt carefully, for the dentist was one with a great and just reputation), and the necessary concealment seemed ensured. From the time of the operation, however, he had severe pain in the stump, which pain increased for four or five days, when he left Paris for Rouen. Upon arriving there the pain had become excessively severe. He consulted a medical man, but it was too late. Trismus came on within twenty-four hours, and was soon followed by tetanus and death."

Tetanus following Filling of a Tooth with Gold.—Mr. A. J. N—— reports[2] the following fatal case of tetanus: Mrs. G——, æt. 27, called to have a carious tooth extracted. On examination it was found to be the left inferior second bicuspid. After its removal there was exposed a large amalgam filling in the anterior part of the left inferior first molar which had been put in years before. All around it the tooth was decayed. Upon being advised as to the condition of the tooth, the patient consented to have the amalgam removed and a gold filling inserted. The amalgam was removed: the pulp was dead, and had sloughed off, the pulp-canals not having been filled. She stated that the tooth had never given her any pain that she remembered. The cavities were prepared, cleansed with carbolic acid; a small pledget of cotton saturated with carbolic acid was left in each root, the tooth filled with cotton, and finished with Hill's stopping. The following day the tooth was filled with gold. After a week the tooth became very painful; an abscess formed and discharged without giving any relief. On the following day two physicians were summoned, who, after examination, pronounced her to be suffering with tetanus. With the aid of opiates the tooth was extracted, but without any result. She grew worse, and one hour later the jaws were perfectly rigid. Although kept under the influence of chloroform, she died two days later. The

[1] *Lectures on Dental Surgery*, p. 321.

[2] *Dental Cosmos*, March, 1875, p. 165.

patient was *pregnant* at the time. There was also a history of some spinal trouble of several years' duration and an attack of stiffening of the jaws about five years before.

Tetanus following Tooth-extraction.—Dr. Steele[1] reports the case of a gentleman who on the 1st of March had a tooth extracted under the influence of nitrous oxide gas. On the 7th he noticed a twitching of the muscles of the right eyelid and a tendency to be drawn down. In a few days the left eye became similarly affected. A week later there was an inability to separate the jaws. At this time there was retraction of the angle of the mouth, and occasionally clonic spasms of the abdominal muscles. On the 15th there was an exaggeration of all the symptoms: the spasms of the abdominal muscles increased in severity; deglutition was performed with difficulty; a drop of water falling on the chin caused spasms. All medication in the mean while proved useless. On the 16th the patient grew worse, all the symptoms increasing in intensity. The thoracic muscles then became affected; the body was powerfully extended in a straight line, but there was no opisthotonos or emprosthotonos. He was not able to remain in bed during the last two days, and it was only during the interval of the spasm that he could sit in a chair: the rest of the time he was held on his feet and required the windows and door to be kept open. On the 19th he died, almost in a standing position, having just sunk down exhausted by the violence of the spasm.

Tetanus from Carious Teeth.—Dr. P. E. Loder furnishes me the facts of the following case: "Man æt. 35. Three months previous to my first visit he experienced a slight irritation in one of his right upper molars. This continuing for several days, he went to a dentist to have it extracted, which, however, was not accomplished. The pain ceased somewhat for twenty-four hours. But two days after he noticed a slight twitching of the muscles of the left arm, which continued for several weeks, and gradually passed away. The night previous to my visit he had been exposed in a cold rain. When I saw him he had slight fever and great pain, which he located in the præcordial region, and spasmodic contraction of the muscles of the upper and lower extremities at intervals of twenty minutes. There was constant stiffness of the muscles of the back of the neck and spasm of the muscles of mastication, which, however, was remittent, never passing off entirely. From this condition he recovered after two weeks. The tooth was removed as soon as the mouth could be opened sufficiently. One year after this I was again called to see the patient, when I found him suffering with a fully-developed attack of tetanus. The paroxysms of muscular spasms followed each other in rapid succession. Again the patient stated that for several days he had suffered from irritation and pain in an upper molar, and after exposure the spasms set in. There was considerable trismus. The patient recovered after two weeks' illness. In both teeth the pulp was exposed."

Dr. Henry Leaman related to the writer the history of a case of tetanus occurring in a young girl, aged seventeen, which was caused by a dental lesion. She had many of the well-marked symptoms of the dis-

[1] *Cincinnati Lancet and Observer*, August, 1869.

ease—viz. trismus, muscular spasms, opisthotonos, and increased reflex excitability. As there was an absence of the usual causes of the disease, and as the patient complained of severe toothache, the thought suggested itself that the cause might lie in the diseased condition of the tooth. This was found to be the case, for upon its removal the symptoms soon subsided.

C. Affections of the Cerebral Centres.

1. Headache.

It has long been known by ophthalmologists that errors of refraction and abnormal ocular conditions are fruitful sources of headache. If not an equally common cause, disorders of the teeth are certainly next in importance to those of the eyes in producing this troublesome affection—an affection which from its frequency and persistence may be charged with being the source of a great part of the pain and discomfort of the world. In a general way, almost all writers have recognized the teeth as one of the causes of headache. Among the more explicit and accurate observers of this source is Dr. T. Lauder Brunton. In a very instructive paper[1] upon this subject he cites several interesting cases, closely maps out those cerebral regions that are affected most by the various peripheral organs, and goes into the discussion of the *modus operandi* of the reflected or induced disorder. His attention was first directed to the connection between the teeth and headache by the case of a family servant in whom there was both toothache and pain in the temple, the latter being the most severe. A pledget of cotton wool soaked with carbolic acid was placed in the aching tooth, but without any result. Later, the girl changed the pledget from the aching molar to another decayed tooth, when the pain at once vanished both from the tooth and the temple. This case was instructive as an instance of the fact that a decayed tooth may cause a sensation of pain in another tooth and in a remote region, whilst the tooth itself remains painless. Later, Dr. Brunton verified the more common fact that there may be headache caused by dental disorders without any toothache. He observed this in his own case: by careful search he found a tender spot under the angle of the jaw in addition to that of the temple, and an enlarged gland at that spot led him to examine the mouth and teeth. Probing and percussion disclosed a carious condition of the last molar on the same side as the headache. So commonly has this fact been noticed that it has become his rule that in all cases of headache the first thing to do is to carefully examine the teeth.

Referring to the location of headaches of dental origin, Dr. Brunton concludes: "I find that a decayed molar in the lower jaw usually gives a temporal or an occipital headache, and a decayed molar in the upper jaw causes a temporal headache which is rather farther forward than that caused by the lower jaw. Decayed incisors or eye-teeth are more likely to cause frontal or vertical headache." As to the method whereby the dental irritation sets up cerebral pain, Dr. B. thinks it is through the action of the sympathetic system on the vessels, which causes a vascular

[1] *St. Bartholomew's Hospital Reports*, vol. xix.

spasm: this spasm is limited in extent, while at other parts the artery (carotid or temporal) is widely dilated, and the jets of blood from the dilated portion hammering upon the contracted part give rise to the local pain, which can be relieved by local applications, heat, cold, pressure, etc., or can be changed to other positions with rapidity. The superior cervical ganglion, whence the carotid and its branches derive their vaso-motor branches, is believed to be the one disturbed by dental irritation. The following cases will serve to further illustrate these phenomena:

Headache from Carious Tooth.—Dr. Brunton records the following case: "Some time ago a clergyman of my acquaintance began to suffer from headache so intense as to completely incapacitate him. After taking various medicines in vain, he went for a Continental tour, but came back little benefited, and as soon as he resumed work the headache was as bad as ever. Shortly after his return I saw him, and, remembering my own experience, I suspected his teeth. On looking into his mouth, however, I could see nothing; all his teeth seemed to be perfect. I then took a steel bodkin and probed and percussed each tooth in succession. At last I came to one which was tender. I advised him to see a dentist about it. This he accordingly did, and the tooth was found to be carious. It was at once properly stopped, and the headaches disappeared."

Violent Neuralgic Headache caused by Impacted Canine Tooth.—The following case, reported by Mr. James Salter,[1] is a remarkable illustration of the severe and prolonged neuralgic headaches, the result of continual irritation from the impaction of teeth. The patient was a young lady: "All the permanent teeth appeared in due course and in regular position, excepting the left upper canine, and the space which it should have occupied was obliterated by the contact of the lateral incisor and first bicuspid. At the time when the right upper canine appeared a hard swelling was noticed in the palate on the left side and toward the front of the mouth, and this slowly developed into a prominent rounded ridge extending obliquely behind the left incisors and left first bicuspid. Mr. Cartwright pronounced this to be the region occupied by the missing canine, and that the swelling was caused by its presence. No inconvenience was at first occasioned by this condition, and the patient was in good health up to the age of eighteen, when she was attacked with severe headache of a peculiar kind. It usually came on immediately after breakfast, and was attended with extreme prostration of strength; it continued the greater part of the day, and recurred sometimes three or four times a week; the pain was always confined to one spot, the vertex of the head toward the left side, and over a circumscribed region about the size of a crown-piece: it was attended with local heat, and was relieved for the time by pressure with the hand. This condition lasted for many years, from the time that the patient was eighteen years of age till she was twenty-six, and during this period she was under constant medical and surgical treatment for her painful affliction, but received no appreciable relief from any of the means adopted. . . . . After many years of suffering and ineffectual treat-

[1] *Guy's Hospital Reports*, 1868.

ment she conceived an idea—or, rather, under the influence of certain not very accurately defined feelings, she had a strong impression—that the impacted tooth in the palate was in some way connected with her sufferings, and she desired to have it removed. The swelling in the palate had gradually become more distinct and prominent, though there was no attempt at tooth-eruption; indeed, the tooth was still covered in by compact bone. It was not the seat of actual pain, but upon the supervention of the headaches the region about it became tender and hot, and, to use the patient's own expression, 'I had an indescribable feeling that the tooth and the headache were connected together. When the hot throbbing came into my head, I always felt conscious of the existence of my shut-up tooth; at other times I did not think about it.'" At the request of the patient a portion of the bone was cut away by Mr. Cartwright and the tooth removed. Its extraction "was followed by complete and permanent relief; the headache vanished from that day, and has never recurred."

Neuralgic Headache from Exostosed Roots.—Dr. Castle[1] records this case: "Miss R—— previous to neuralgic attacks was a young lady of fine healthful appearance, fifteen years of age. She had been subject to nervous headaches and acute pains in the right eyeball and temple to the sagittal suture, along its line, and down the whole spinal column, leaving a dull aching lumbago. The paroxysms were exceedingly severe, occurring every other day, sometimes missing the alternate day. Frequently on these occasions, during the violence of the paroxysms, all use of the lower limbs would be lost; at other times simply a numbness of the extremities would be produced. . . . . I carefully examined each tooth, striking them severally with a steel sound. Upon striking the right cuspidatis she experienced acute pains in the eyes and temples and a loud sounding noise in the ears and head, as of the dying reverberations of a gong or bell. One tooth had been filed down the side through the enamel to the bone; touching this, the left cuspidatis, with a sharp-pointed instrument, the pain was excessive, giving that nervous sensation of the 'blood running cold,' and as if the whole body would draw itself up into a corrugated ball: the right cuspidatis had been scraped at its neck. I extracted these teeth, and with the loss of the teeth her afflictions vanished." The teeth in this case were found to be diseased and somewhat exostosed.

Inveterate Headache caused by Carious Teeth.—"Hildanus[2] had a patient who for a long time had been afflicted with a severe and continued pain in the left side of her head, particularly in damp weather. For six months previously she had suffered with severe pain in the teeth of the left jaw. After this period the pain somewhat abated, but was followed by violent pain in the corresponding side of her head. Upon the supposition that there might be some connection between the carious teeth and the headaches, they were removed, with complete relief to the patient."

Persistent Headache the Result of Exostosis.—Dr. E. C. Baxter[3]

[1] *London Lancet*, 1846, p. 267.
[2] Quoted by Dr. Bond, *Treatise on Dental Medicine*, 1851.
[3] *Dental Cosmos*, May, 1872.

records the following case: "A patient, a lady of middle age, called for the purpose of having a cavity filled in the right superior cuspid, having just discovered that it needed attention by the breaking in of the distal wall; she expected to have it filled at once. On examination I found the pulp dead, and an abscess established which was discharging through a fistula between the cuspid and bicuspid, allowing the passage of a broach up the side of the root to its apex. The other teeth were all in good condition except the right superior first molar and left inferior first molar, the former having lost almost all its crown, and the crown of the latter being entirely gone, leaving the two roots standing separate. During the examination the patient volunteered the information that for three years she had been under treatment for continual headache, from which she was never free half a day at a time, and which any extra excitement or over-exertion brought on so severely as to confine her to bed for days, when she would suffer the most excruciating agony. Neither of the teeth had ever caused any trouble, with the exception of slight tenderness of the cuspid to pressure. The advice based upon the general bad condition of the teeth in question, and the possibility of something occult connected with them, was the removal of the upper and lower molars and treatment of the cuspid for the cure of the abscess; but, having merely contemplated the filling of a simple cavity, she desired before submitting to the operation the advice of her physician, who subsequently called with her, and upon being shown the condition of the teeth coincided with the advice given. The operation was commenced by the removal of the roots of the lower molar, which, being entirely separate at the margin of the gum, were expected to be removed one at a time, but in the attempt to remove the anterior root both came away together, revealing such a marked case of exostosis as the joining of the ends of the two roots in one large mass. Considerable difficulty was experienced in removing the roots of the superior molar, the buccal roots being joined the same as the lower molar roots, bringing away that portion of the alveolus embraced by them, and the palatine root also showing considerable enlargement. This development of exostosis justified the assurance given to both patient and physician that the cause of her suffering had been brought to light." After treatment of the abscess the patient entirely recovered.

2. Epilepsy.

Whatever be the nature of epilepsy, there is a growing belief that its essential feature is of the character of an explosive discharge from the higher nerve-centres, which passes outward through motor nerve-channels with such an excess of energy that there results inco-ordination of movements, convulsions, and spasms. Writers generally assume that the majority of cases are due to heredity, but there can be no doubt that many cases classed as idiopathic are only so as regards the predisposition, and that, this given, only a slight amount of peripheral irritation may be necessary to call forth the explosive discharge. It is fully conceded by all that spiculæ of bone pressing upon the cortex, intestinal worms, uterine troubles, phimosis, wounds, etc. etc. are all not uncommon peripheral causes of epileptic attacks. That dental inflammations

and disorders are more often provocative of the same than is commonly supposed appears quite certain from the following cases, and also from the character of the cause and its effect.

Many reasons might be given why dental disorders are peculiarly adapted to call forth this periodical discharge, and why these disorders are habitually overlooked by the physician; but they cannot be detailed here. As exemplifying these phenomena the following interesting and instructive cases are adduced:

Epilepsy from Carious Teeth.[1]—"A boy thirteen years old has had frequent attacks of epilepsy for the last eighteen months. Latterly, his mother noticed that some days he rubs his left cheek, complaining of faceache, after which the fit follows. On examining the mouth there is to be seen a molar tooth considerably decayed, with a swollen gum around it and partly growing over into the cavity: it is not very tender to the touch, and the examination does not give rise to toothache. On questioning, I find the sensation which the boy experiences before the fit does not seem to be one of pain, but rather of indefinite uneasiness. He always has a fit the night this comes on. Has never felt it during the day; it is always about seven or eight o'clock. I desired the mother to have the tooth extracted, and ordered a simple saline, with a quarter of a grain of belladonna, to be taken twice daily. This was in June. The tooth was extracted next day. I saw this boy once a fortnight from that time for four months, but he had no recurrence of the fits. In this case I believe an unfelt aura commenced about the gum surrounding the tooth, and was not recognized till some degree of inflammation arose, and thus a modification of pain became associated with the aura and directed attention to it."

"A lad, a farm-laborer from Windsor, was admitted into the hospital for epilepsy. The usual remedies were tried for six weeks without effect. His mouth was then examined, and the molar teeth of the lower jaw were found to be much decayed, and of some of these only the fangs remained. He did not complain of pain in the diseased teeth or in the jaw. The decayed teeth were, however, removed, and the fangs of each were found to be enlarged and bulbous from exostosis. During the eighteen months that succeeded the removal of the diseased teeth he had not suffered from a single fit, though for many weeks previous to the operation he had two or three per day."[2]

Trousseau[3] relates the case of a patient, a young notary's clerk, under the care of Dr. Foville, who had been subject to monthly attacks of epilepsy for several years. Many remedies had been tried in vain. Dr. Foville suggested the extraction of some carious teeth which ached constantly. The suggestion was acted upon, and from that day the fits disappeared.

Epilepsy from Irritation of Gold Plate.—Dr. Garrett related the following case before the Suffolk District Medical Society, and was reported by Dr. Page:[4] "A man aged forty to fifty years had suffered with his teeth for years: these had been extracted and artificial ones substituted.

[1] Dr. Ramskill, *Med. Times and Gazette*, 1862, vol. ii. p. 216.
[2] Dr. John Tomes, *System of Dental Surgery*, p. 509.
[3] *New Sydenham Soc.*, vol. i. [4] *Boston Med. and Surg. Journal*, Nov. 8, 1860.

He became paralyzed in the muscles of his face and tongue. There was a peculiar drawing of the mouth, from which the aura epileptica came just previous to the fit; the tongue was inclined to fall back within the mouth; he was fearful of swallowing it. In investigating the case Dr. Garrett removed the false teeth and found the soldering discolored: he went back to his dentist, had a rubber plate made, and had no further attacks of epilepsy: the paralysis gradually subsided."

Epileptoid Convulsions of Right Arm from Carious Teeth.—Dr. J. W. Booth[1] relates the following case of epileptoid convulsions occurring in an unmarried woman: "She had epileptoid convulsions, affecting principally some of the muscles of the neck and right arm. These attacks had been of almost daily occurrence for four years. She had nearly continuously during this time taken many remedies empirically, the cause of her affection not having been ascertained, without the slightest appreciable benefit. There was a very slight disposition to anæmia, and beyond this there was not a symptom upon which to base a diagnosis or therapeutic indication. Appetite, digestion, general health, all good; circulatory and generative apparatus acting normally. Inquiring into the history of the case, she stated that her first spell came on during an attack of toothache. Upon examining her mouth, we found half a dozen carious teeth, and determined that to extract these teeth would afford the best chance of relief. Accordingly, all the carious teeth were promptly extracted. There has been no return of the convulsions since. This lady is now improved considerably in flesh and presents no anæmic phenomena. I need hardly say that her spirits are improved in the same degree."

Cases similar to the above, depending for their cause upon diseased teeth, and completely cured after their removal, have been reported by Drs. Castle,[2] Waite,[3] Field,[4] and Rush.[5]

3. Hysteria.

Hysteria may be defined as a functional disorder of the nervous system characterized by convulsive paroxysms, with, at times, apparent loss of consciousness. It is most frequently accompanied with motor, sensory, and intellectual disturbances, which may simulate true organic disease of the nervous system. Whatever may be the pathology of hysteria, there appears to be present in all cases a predisposition to the disease which is usually hereditary. This consists in an unusual mobility of the nervous system which renders it peculiarly liable to disturbances of equilibrium. While it is commonly admitted that this constitutional condition is hereditary, it is also well known that it can be induced by sickness, insufficient nourishment, diseases of the uterus, ovaries, etc. When the predisposition is established, almost any continuous peripheral irritation may disturb the equilibrium of the now irritable nervous tissue, with the result of producing every conceivable variety of motor and sensory disturbance. In this disease, as in so

[1] *American Journal Med. Sci.*, Jan., 1870.
[2] *Lancet*, Jan., 1848.
[3] *British Journal of Dental Science*, 1863.
[4] *Western Journal Med.*, quoted in *Dental Cosmos*, xi. 328.
[5] *Medical Enquiries*, vol. i. p. 199.

many others, we find that morbid conditions of the teeth not infrequently act as exciting causes of the paroxysms.

The following cases are presented as illustrations of hysteria the result of dental irritation:

Hysterical Convulsions caused by a Pivot Tooth.—Dr. C. Lederer[1] reports the case of a strong, healthy girl who had by his advice an artificial tooth pivoted in the left upper jaw in place of an extracted incisor. Soon afterward the girl was seized with hysterical attacks and convulsions that broke her health and kept her in bed most of the time. At this time the patient was absent, but the doctor, hearing that she was suffering from hysteria, had his suspicions aroused, and (after many other physicians had been called in and failed to give any relief) he ordered the artificial tooth taken out, and as if by magic every symptom of hysteria and paroxysmal attacks disappeared immediately, and only reappeared when later there was another attempt made to wear the tooth again.

Dr. Lederer adds that he believes that irritations of the vagus from dental troubles are also quite common, but that the cause is not recognized.

Hystero-Epilepsy.—Dr. Ashburner records[2] the following case of a young woman nineteen years of age, with light hair and fair complexion, who led a very sedentary life. As a consequence she suffered very considerably from constipation. For several months her health had been impaired, as shown by profuse sweating at night, disordered stomach and bowels, and restless sleep. She was suddenly seized with a fit, for which her physician, Dr. Nutall, caused her to be profusely bled. Three weeks later Dr. Ashburner was called to see her, as she was again in the same condition. He states: "I learned that she had been very odd and nervous in her manner, and had often suddenly screamed out from cramps seizing her toes and the calves of her legs, which were succeeded by her thumb being drawn inward toward the palm of her hand and her fingers being clenched upon it. I found her in a state of tetanus. The convulsion over, I thrust my forefinger into her mouth, where I found the wisdom teeth of the upper jaw through. In the lower jaw the teeth could not get through, for there were hard, cartilaginous substances in their way. Through these I scored freely, and the young woman was relieved instantly."

Hysteria caused by Irritation of a Pivot Tooth.—Dr. Richardson[3] relates this case: "A young lady on whom I was once in frequent attendance for hysteria, and in whom the symptoms were easily excited, was taken suddenly ill with a convulsion which had more than hysteric meaning and which was persistent. In the intervals of calmness, which indeed were few, I endeavored from the immediate history of the symptoms to gain an insight into their cause. At last she admitted to me that she was in pain in the mouth, and, bit by bit and on pressing the necessity of examining the mouth, I learned that the day on which the symptoms appeared a false tooth had been provided; that soon after the operation intense pain resulted; that in her desire to conceal the

[1] *Wiener Medizinische Presse*, June, 1866.
[2] Richardson, *Diseases of the Teeth*, p. 93.
[3] *Op. cit.*, p. 94.

fact of an artificial front tooth she had borne up against the pain until the hysteria, epileptiform in reality, was the result. I insisted on instant removal of the new and offending cause, with the effect of entire and rapid subsidence of the symptoms."

Dr. Richardson also mentions another case of a young girl who came under his care for hysteria of an epileptiform character. Various remedies had been tried for some time without any benefit. Finally, after great pain, she erupted a wisdom tooth, after which she lost all her hysteric symptoms. He states that he never meets with a case of hysteria now, "if the excitant seems to be local, without asking in the most solicitous manner after the wisdom teeth."

4. Chorea.

Notwithstanding the fact that chorea frequently occurs during the period between the first and ending of the second dentition, it does not appear that the irritation of the nervous system caused by this process gives rise to any number of cases of chorea. In but few of the standard works on nervous diseases is the eruption of the teeth ever associated with the appearance of choreic movements. Yet the few cases which I have been able to collect go to show that dentition may be regarded as one of the many influences concerned in the production of this disease. By some writers it is thought highly probable that chorea may be so caused. Thus, Dr. Tweedie[1] says: "The disease (chorea) is occasionally induced by the irritation accompanying the second dentition." Dr. West[2] says: "Sometimes chorea seems connected with some irregularity in the second dentition." Levick[3] states as his belief "that the irritation connected with the teeth would seem to have more to do with the development of chorea than one would at first suspect." Eulenberg[4] states that he has "on several occasions found the disease, when due to dental disorders, disappear after the extraction of the carious teeth, and again make its appearance upon the development of fresh troubles in the teeth."

The following cases are illustrative:

Chorea cured by Tooth-extraction.—Dr. J. T. Villard[5] records a case of chorea in a young lady whom he was called to see in consultation by Dr. Ritchie. Upon examination he found the patient to be suffering from St. Vitus's dance, and as the attending physician thought the trouble to be due to carious teeth, he examined the mouth and found several stumps in both jaws: the gums entirely covered some of them, pressure on which gave her much pain and increased the violence of the movements. Pus also exuded from the gums on pressure. After administering ether, eight stumps and some small pieces of dead alveoli were removed. From that time the paroxysms gradually grew less, and the patient was entirely restored to health.

Chorea from Persistence of Deciduous Teeth.—The following case was related to the writer by Dr. C. N. Pierce: Boy æt. 9 years; has always been in good health until about two months ago, when he was attacked

[1] *System of Medicine*, art. "Chorea."
[2] *Diseases of Children.*
[3] *Amer. Journ. of Med. Sciences*, Jan., 1862.
[4] *Lehrbuch d. Nervenkrankh.*, vol. ii. p. 669.
[5] *Dental News Letter*, Oct., 1855.

with choreic movements, chiefly in the muscles of the face, though present also in the muscles of the neck and shoulders. Owing to their local character and the absence of the causes usually assigned for the appearance of chorea, it was thought possible that the condition of the teeth might offer some explanation of the trouble. Careful examination of the mouth revealed, in addition to considerable overcrowding of the teeth, persistence of the deciduous incisors. Upon their removal the choreic movements at once subsided. After an interval of a year there was a return of the symptoms. Examination of the teeth again showed a persistence of the deciduous molars, delaying the eruption of the bicuspids. Removal of the offending teeth was followed by complete recovery.

Chorea from Dental Caries.[1]—The following case is reported by Dr. Malden: "Ann Fowler, æt. 24, was attacked with chorea, which was confined chiefly to the right side. The muscles of the face, arms, and shoulders were in continual movement. These symptoms had existed for six weeks, and were increasing in severity day by day. The patient stated that two years before she had had the same disease, following an attack of toothache; also, that the movements had ceased after she had the carious tooth removed. Attention was then directed to the mouth, and it was found that the wisdom tooth in the inferior maxillary of the right side was markedly carious. Pressure did not produce any pain, but augmented the intensity of the convulsive movements. The extraction of the tooth was at once followed by a cessation of the spasmodic twitchings, and the patient was shortly cured."

Chorea from Non-erupted Molars.—Dr. Ashburner records the following case:[2] "A boy twelve years of age was cutting the second or posterior permanent molars of the upper jaw before those of the lower, and the process was accompanied by twitchings of various parts of the body. At last he became affected with chorea. Being a very nervous lad, if any notice was taken of him he would quite involuntarily make the most extraordinary grimaces and contort his body into attitudes that appeared to be most difficult and painful. His chorea continued for three months, during which time a variety of medicines was swallowed. At last he fell into an epileptic fit, struggling much, foaming at the mouth, and grinding the teeth. I thrust my forefinger along the inside of his cheek and found a hard, cartilaginous space on each side behind his first molar teeth. I succeeded in gashing these parts: he uttered a scream and fell out of his fit, becoming quite sensible, nor has he had a recurrence of his chorea."

5. Insanity.

The occurrence of insanity as a result of the pain and irritation caused by the eruption of the teeth was first noticed and commented upon by Esquirol.[3] He says: "Among subjects of a lymphatic and nervous temperament the pains of the first dentition sometimes become the cause of insanity. The appearance of the teeth through the gums causes all the symptoms to cease. I have observed this in the case of three young

[1] *Transactions of the Provincial Medical and Surgical Association*, vol. xix.
[2] Quoted by Richardson. *Disease of the Teeth*, p. 92.
[3] *Insanity*, Am. ed., 1845, p. 197.

girls: they had convulsions, bloating of the face, discharge of saliva, and often raised their hands to the mouth. I could not be deceived respecting the cause of this malady in the first of the three patients: the delirium ceased at the end of a month and two teeth had pierced their envelopes. Fifteen days afterward the mania reappeared with the same intensity. The gums of the late tooth were swollen and very red. The attack lasted several months, and ceased only on the appearance of the teeth."

Dr. Maudsley,[1] in commenting upon the relation of morbid bodily states to disordered mental functions, states: "In some instances we observe a curious connection between insanity and neuralgia, not unlike that which, existing between epilepsy and a special form of neuralgia, induced Trousseau to describe the latter as epileptiform. I have under observation now a lady who suffered for some time from an intense neuralgia of the left half of the face: after the removal of a tooth suspected to be at the root of the mischief the pain ceased, but an attack of melancholia immediately followed."

The following cases will serve to illustrate the connection between morbid conditions of the teeth and disordered mental states:

Insanity from Irritation of Pulp-nodules.[2]—"A lady aged forty, married, family history good; good physique, but of nervous temperament. Had always been well until about a year ago, when she began to exhibit considerable mental aberration attended with periods of great depression of spirits. This condition had lasted almost continually for one year. From time to time during the year she complained of severe radiating pains in the right side of her face and head. Localized tenderness of the inferior right molar induced me to open the pulp-chamber. It was found that the pulp was devitalized, and contained a number of nodules. Upon the removal of this source of irritation the melancholic condition disappeared completely. She remained well for two years, when in consequence of peculiar domestic troubles she again became insane, and died in an asylum."

Insanity from Overcrowding of the Teeth.—Mr. D. Corbett[3] relates the following case: "A little girl aged thirteen, of weak intellect from infancy, was docile and tractable until the period of the second dentition, when a marked change was observable in her conduct and disposition. She became at times violent and subject to paroxysmal attacks, causing her to run about the room, biting at everything within her reach—chairs, tables, and door-handles. In the street she would run off from her attendants and attempt to bite the lamp-posts. Her teeth appearing to require attention, the child was brought to me for advice by her guardian, who gave me leave, should it be necessary, to remove any teeth, but to be prepared for unusual resistance on the child's part, and act accordingly. I found the incisors of the lower jaw overlapping each other, as also the cuspidati pressed forward in a most unbecoming manner. I at once removed the first bicuspid on each side, and directed the child to be brought to me after a month's interval. This was done,

[1] "Gulstonian Lectures," *Lancet*, 1870.
[2] Related to the writer by Dr. C. N. Pierce.
[3] *Transactions of the International Med. Congress*, 1881, p. 475.

when I learned that though no improvement had been observed in her mental condition, the biting propensity had completely disappeared."

Mania from Carious Teeth.—The following cases were related by Dr. Tyler[1] before the Boston Society for Medical Improvement, and led him to attach great importance to the relation between decayed teeth and mental disorders:

"A boy, æt. 19, was brought to the New Hampshire Asylum in a state of mania. Dr. Tyler ascertained that he had had a tooth extracted some time previously, and that one of the fangs had broken off and remained in the jaw. Suppuration then took place, the pus discharged outwardly, and the boy was suddenly attacked with mania. The fang was removed, the fistulous opening closed, and the patient quickly recovered from his mania."

"In a second case of mania the patient, a young lady, had several decayed teeth removed: the patient remained under the influence of the ether which was given at the operation for twenty-four hours; after that she was cured of her mania."

Insanity from Exostosed Root.[2]—"The patient, a gentleman, had suffered for many years from what had been supposed to be neuralgia, which finally produced insanity. Under these circumstances he was brought to Dr. Harvey to have a tooth extracted. With great difficulty, and only after applying extraordinary force, he removed this tooth, which was found to be sound, but there was seen attached to it, growing from its roots near the crown, a round, smooth, solid tumor of bone about the size of a filbert. The neuralgia immediately ceased, and the patient was soon restored to sanity."—Related by Prof. Hamilton.

Insanity caused by Irritation of Carious Teeth.—Dr. D. T. Pepper of Manayunk has sent me the notes of the following interesting case: "In the fall of 1880, I was called upon by a physician to visit and examine the mouth of a patient suffering with mania, with distinct paroxysms and complicated with violent neuralgic pains. It was supposed by the attending physician that the condition of the teeth might have something to do with the production of the paroxysms. I found the patient in bed and kept under proper restriction and treatment. The attacks of neuralgia were paroxysmal, coming on at intervals of about fifteen minutes and lasting from five to ten minutes, during which he would seize a rod suspended by a rope and pull upon it with all his power. After careful examination I concluded to remove all the carious teeth in the lower jaw of the left side, where all the pain seemed to be located. This was done, and in a short time the patient was cured. The trouble again returned after three weeks, when it was agreed to remove a portion of the inferior dental nerve, which was supposed to be more or less inflamed. This was done, about half an inch being removed, and the patient was permanently cured of all his trouble."

[1] *Boston Med. and Surg. Journal*, Aug., 1862.
[2] *Buffalo Med. and Surg. Journal*, Oct., 1860, p. 67.

INFLAMMATION OF THE MUCOUS MEMBRANE OF THE ORAL, NASAL, AND PHARYNGEAL CAVITIES.

By W. X. SUDDUTH, M. D., D. D. S.

Stomatitis.

Stomatitis, as the name implies, is an inflammation of the oral mucous membrane.

We will consider—

I. The structure of the oral mucous membrane;

II. Inflammations of the oral mucous membrane as a class—viz. catarrhal, croupous or diphtheritic, ulcerative, and gangrenous;

III. Inflammations of the oral mucous membrane as individual members of a class—viz. catarrhal, acute and chronic aphthous, thrush complicating aphthous, ulcerative, and gangrenous.

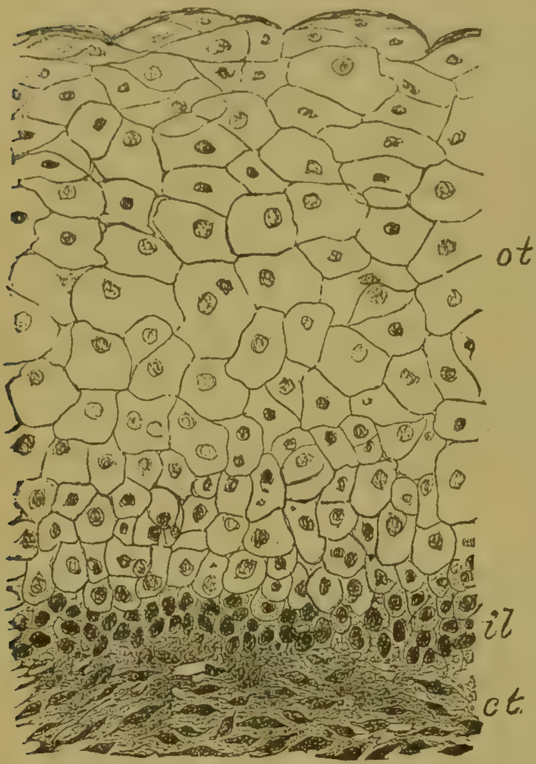
I. *Structure of the Oral Mucous Membrane.*—The oral mucous membrane and the skin are analogous products of the external layer of the blastoderm. They are continuous, the one with the other, at the lips, and present the same anatomical features with but few exceptions. The buccal cavity is constantly bathed with the secretions of the mucous glands, which prevents the oldest layer of cells from presenting the corneous nature found in the outer layer of the skin; otherwise, with the exception of that portion covering the tongue, the description of the mucous membrane of the mouth would answer for the skin, or *vice versâ*. The terms usually applied to the several layers of the mucous membrane of the buccal cavity differ from those applied to the same layers of the skin; for instance, we speak of the deepest layer of the mucous membrane of the mouth as the submucous layer or stroma, while the same tissue in the skin is called the corium or true derm. The oral mucous membrane consists of the stroma, which forms the framework, the epithelial cells covering it, and the glands, lymphatic and nutrient vessels which lie imbedded in the substance of the stroma.

The surface of the stroma is covered with papillæ, which, with the exception of those found on the tongue, are identical with those of the skin. The spaces between the papillæ are filled with epithelial cells, that imbed the uneven papillæ and form an outwardly smooth surface.

The deepest part of the epithelial layer of the mucous membrane of the mouth is formed by a layer of protoplasm, which is conspicuous in specimens stained with hæmatoxylon and eosin, in that it stains more

darkly than the surrounding tissue: in this protoplasmic basis substance are found the youngest epithelial cells. In some instances they are arranged in a single layer, in which case they are somewhat oval in shape; in other instances the dark-stained layer of protoplasm is wider, and several layers of spheroidal cells exist—not arranged in strata, but presenting an irregular appearance. (See Fig. 138.) In a normal condition of the mucous membrane there is a constant production and subsequent desquamation of the oldest cells of the epithelial layer. If you examine the saliva with the microscope, you will find epithelial cells.

Fig. 138.



Vertical Section of Mucous Membrane of Mouth (7 cm. porcine embryo × 250): *ot*, older layer of cells; *il*, infant layer of cells; *ct*, connective tissue of mesoblast.

Desquamation is a physiological process, and takes place slowly: a too rapid shedding or casting off of the epithelium gives rise to a pathological condition. In a normal condition the glands of the mouth are constantly secreting mucus, but only in sufficient quantity to lubricate the surface and subserve the process of insalivation of food.

II. *Inflammations of the Oral Mucous Membrane treated as a Class.*—We recognize four forms of inflammation affecting the buccal mucous membrane: catarrhal, croupous or diphtheritic, ulcerative, and gangrenous. These may be classed, as—1, idiopathic, or inflammations in which the initial lesion is presented in the mouth; 2, symptomatic inflammations, in which the local lesion is the expression of a constitutional disease.

In idiopathic inflammations we have, usually, both local and general symptoms. There are present the local signs of inflammation—viz. redness, heat, pain, and swelling. If the lesion is sufficiently grave there will be a febrile movement, which may be preceded by rigors, but the general symptoms are dependent upon the local inflammation.

In symptomatic inflammations of the mucous membrane of the mouth the local lesion is the inflammatory complication of a general disease, and there are present two distinct sets of symptoms—one dependent upon the local, the other upon the general disease.

In the simplest forms of inflammation there is a loss of the superficial epithelium and the production of pus-corpuscles, which rapidly accumulate on the surface of the epithelium and mix with the saliva. Such inflammation is ante-mortem, as no change after death can be discovered in the tissues. On the other hand, we have inflammation, diphtheritic, in which there is the production of pus, fibrin, and serum,

which in addition to the external exudation are infiltrated into the connective tissue of the stroma, and present pathological alterations in the tissues that are discoverable at the post-mortem. Again, we have cellular inflammation, which is characterized by the production of new cells: in this latter form of inflammation the blood-vessels take very little part, but in the former, with the production of pus, fibrin, and serum, the blood-vessels are principally concerned. It is from the blood circulating in the blood-vessels that the exudation is derived. There are regular pathological changes to be observed in the blood-vessels. There is a determination of blood to the part, with consequent exudation upon the surface or infiltration into the substance of the tissues of pus, serum, and fibrin. The relative proportion of these inflammatory products varies very greatly in different cases.

The earliest stages of inflammation can be observed in the tip of the tongue of a living frog: to make the experiment place a few drops of an aqueous solution of curare on a frog's tongue; after the frog is under the influence of the drug place it on the stage of the microscope in such position that the circulation can be easily examined. It will be observed that the blood is flowing quite rapidly in the arteries, veins, and capillaries, the red and white blood-corpuscles floating in the blood-plasma: in the larger vessels the red blood-corpuscles are arranged in the centre, while the white blood-corpuscles are traversing the peripheral portion: in the smaller vessels and capillaries this regular arrangement is broken up and the red and white corpuscles are found to be irregularly arranged. Then apply a drop of dilute nitric acid to the surface of the tongue and note the result. The blood begins to circulate more slowly than normal, especially around the peripheral portions of the vessels, while the central column is denser, yet it continues to circulate slowly. If it were not for the continuance of the circulation of the red blood-corpuscles in the centre of the vessels, the migration of the white corpuscles would not take place.

The white blood-corpuscles begin to adhere to the walls of the vessels, especially in the larger veins. The vessels dilate, and there is a marked increase in the number of corpuscles, both white and red.

If the observation is continued a sufficient length of time, the external walls of the veins and capillaries will present a nodular appearance: they will no longer appear smooth, as in their normal condition. The surface of the tongue at this stage of the observation will be seen to be covered with a semi-transparent membrane which can be scraped off, and if it is examined it will be found to consist of pus-cells, fibrin, and serum. Turning our attention again to the capillaries, we will be enabled to see where these corpuscles came from. As we have seen, the white blood-corpuscles were in a state of almost complete stagnation: this becomes complete, and they attach themselves to the walls of the vessels. After they have become adherent for a short time, we will begin to see little knobs on the outside of the capillaries, which gradually become larger, and the adherent white corpuscles on the inside will become smaller; the corpuscles now present a dumb-bell shape, balanced in the wall of the vessel; finally, the part that was inside the capillary is found

to be entirely outside, and the surrounding tissue becomes infiltrated by this process.

What we have seen take place in the capillaries we infer occurs in the veins, but on a larger scale. Not only the white, but the red, blood-corpuscles migrate through the walls of the vessels.

From this study it is to be inferred that the pus-globules are modified white blood-corpuscles. The fibrin, which we find coagulated on the

Fig. 139.

Inflamed Human Omentum. The phenomena of inflammation are seen in the veins and capillaries, the condition being normal at the artery (*c*), where *b* represents endothelium covering the trabecula (*a*); in the vein (*d*) there are many white corpuscles along the wall; some of these are emigrating (*e*); *f*, desquamated endothelium; *g*, extravasated red corpuscles.

surface of the tongue and in the interstices of the connective tissue, is formed by a union of certain elements found in the plasma of the blood and the degenerating white blood-corpuscles. The serum is derived from the plasma of the blood. In a certain number of cases the amount of pus and fibrin accumulated will be so extensive as to compress the blood-vessels, complete stagnation resulting: when this is the case a portion of the mucous membrane will die, degenerate, and slough away.

It is in this manner that ulcers are formed, and vary in size and depth according to the extent of tissue infiltrated by the pus and fibrin and the size of the vessel in which stagnation has occurred. The ulceration may be superficial or deep, dependent entirely upon the extent of tissue involved in the congested area.

The blood-vessels may be primarily affected by deleterious agents carried in the blood; in this case the surrounding tissues suffer secondarily. In the second place, tissues and vessels may be injured simultaneously. In the third place, the primary lesion may exist in the tissues and the injury to vessels be secondary. The exciting causes which may result

in inflammation are beyond enumeration. Let it be said that any agent whatsoever that has the power of destroying the tonicity of the walls of the vessels in such a manner as to permit the exudation of the blood-corpuscles may result in inflammation. The lesion may be constitutional and the expression local, as in embolism of an artery. It is not essential that the agent be continuous in its action: the latter statement is proved by the following experiment: Place a ligature tightly around the base of a frog's tongue, so as to cut off the arterial supply. After eight or ten hours remove the ligature and again allow the blood to circulate: almost immediately it will be noticed that the tongue is beginning to swell and present a vascular appearance; finally, it becomes œdematous; the white blood-corpuscles migrate in large quantities through the walls of the vessels, and continue to do so although the original injurious agent, the ligature, has been removed. The longer the ligature is left on, the profounder the anæmia and the greater will be the lesion to the walls of the vessels, and consequent infiltration of the tissues—first with plasma, then with white blood-corpuscles, and lastly with the red blood-corpuscles which escape from the capillaries and veins.

This same phenomenon has been witnessed after the removal of Esmarch's bandage, which had been necessarily allowed to remain on for a considerable length of time on account of a tedious operation, although the vessel-walls were more easily injured in the latter instance by reason of their want of tonicity, dependent upon the pre-existing disease which made the operation necessary. The explanation is found in the malnutrition resulting from the interference with the circulation setting up a process of retrograde metamorphosis in the walls of the arteries, capillaries, and veins. If the ligature or bandage had been left on a sufficient length of time, death of the part would have ensued without the process of inflammation having intervened.

To produce an inflammation the exciting cause must not be too severe, but, on the other hand, it must be of such an extent as to produce its effect on the walls of the vessels. An inflammation, once set up, proceeds until the exciting cause be removed or the tissue dies. Resolution is more easily effected in the first stages of inflammation than in the more advanced forms.

Where the injury to the walls of the vessels has not been too severe, they will recover their tonicity, the exudation of the blood-corpuscles and plasma will be arrested, and a healthy flow of blood to the part will be established.

After the progressive stage of an inflammatory action has ceased, we have repair setting in. Hypertrophies, consisting of organized inflammatory products, dead and diseased tissues, may be resorbed. This process of resorption of tissues is so little understood that a brief consideration of the subject in explanation of the manner of its accomplishment may not be considered out of place.

Nature is conservative, retaining only such tissues in the body as are productive of benefit to the animal economy. The process of resorption is constantly going on; cells and tissues, having performed their life-work, are continually being broken down and removed by and through

the lymphatic system. It is not to these conditions, however, that it is desired to direct attention, but to the removal of the products of inflammation, blood-clots, ligatures, and foreign bodies of every nature that become imbedded in the tissues of the body. The removal of such substances is dependent upon the action of specialized cells called resorptive or *giant-cells*, and the process is physiological. The foreign body acts as a stimulant to cellular activity.

In the case of small particles, such as coal and stone, etc., the white blood-cells take them up by flowing around them and carrying them to a neighboring gland, where they are deposited.

Insoluble substances, if not in a high degree irritant to the surrounding tissues, may be encapsuled and held in the tissues. But, nevertheless, Nature makes an effort to remove them. The migrated cells which form the hyperplastic granulation-tissue contain many multinucleated cells, the product of rapid cell-multiplication. Fleming has established beyond dispute the fact that cell-division is dependent upon nucleus-division. In some instances, however, the nucleus divides, and a subsequent division of the cell does not follow. In this case multinuclear or *giant-cells* are formed. Why cellular activity results is not positively known, but it is probable that the cells are stimulated to an increased assimilation of cell-pabulum. But an increased supply of nutrition does not always produce giant-cells. Some authors hold that giant-cells, or *osteoclasts*, found in connection with resorption of bone, are produced from the liberated bone-cells; but the fact that giant-cells appear in connection with the resorption of dead bone and other hard tissues which do not contain bone-cells seems to establish for them an independent identity. Ziegler, when speaking of the erosion of bone, uses the terms osteoclasts, giant-cells, and resorption-cells as synonymous, and asserts that they arise from multiplication of exuded white blood-cells.

The presence of giant- or resorption-cells is general where tissues are to be resorbed, whether it be in the normal development of bone or in the resorption of the roots of temporary teeth. Here they act as Nature's physiological agents in the removal of tissues which have served their life-purpose. In fact, all the processes of Nature are physiological; her agents—cells—are developed to perform well-known physiological actions, and when a pathological result is produced it has its origin in some outside influence. Cells have not the power to produce pathological results unless stimulated by some agent which lies outside of physiological bounds, and when so stimulated they act through their own peculiar channels. Many physiological processes present pathological appearances, but when we study their deeper expressions we find that they are purely physiological. I look upon giant-cells as Nature's physiological agents, by whose aid she removes tissues that have performed their life-office or by their presence are hurtful to the animal economy.

The resorption of tissues through the agency of giant-cells is therefore to be regarded as a purely physiological process. The pathological phase is found, not in the removal of the tissue, but in the irritant which preceded the resorptive process and made it necessary. Thus far, too

much stress has been laid upon the visible expression of Nature's effort to remove the irritant, and too little on the character of the irritant itself. Pathological results may attain to the resorption process through the action of giant-cells by reason of the juxtaposition of healthy tissue. Nature, in her effort to remove the irritant, acts upon the surrounding tissue. This probably occurs more or less in all resorptive processes; it is, however, incidental.

In caries of bone due to extension of constitutional diseases, such as tuberculosis and syphilis, it seems to me that it is perfectly rational, from the knowledge we now possess of the specific vices of these diseases, to say that the cause of irritation lies in the micro-organisms which are found in connection with them. The case is not altogether clear for syphilis, but no doubt exists regarding the direct connection between the tubercle bacilli and tuberculosis. Nature seeks, by the destruction of local territories, to circumscribe the irritant; and when *caries* accompanies this process, it is often the indirect and not the direct point of attack.

In myeloid sarcoma, though giant-cells are present, we have as yet been unable to demonstrate any local irritant. That such a condition does exist in connection with the disease I have no doubt. The action of the giant-cells is the same in all cases: they secrete a fluid which has the power of digesting the tissues in their immediate neighborhood. In claiming this attribute for them we do not go beyond the physiological action of cells.

The process of digestion is well known to every student of physiology. In the stomach, glands secrete certain fluids by whose action that which we call food is so changed that it can be taken into the blood and assimilated by different parts of the body. A failure on the part of these glands to produce their normal fluid will cause what we term indigestion. Ordinary food-stuffs, unless prepared and dissolved by the fluid secreted by the glands, cannot be assimilated. We find that what is true of the digestion of food is also true of the digestion of tissue. In order that a tissue may be removed, it must first be digested by the cell-fluid, after which it can be taken up by the lymphatic system. It is true that very small particles, by reason of their minute subdivision, do enter the lymph-channels, but they are not assimilated into the general system: they are deposited in the first gland into which the lymphatic empties. Instances of this kind are found in cases of respired particles of coal- and stone-dust, and as a consequence we have the pathological condition known as the "coal-miner's" and "stone-hewer's" lung.

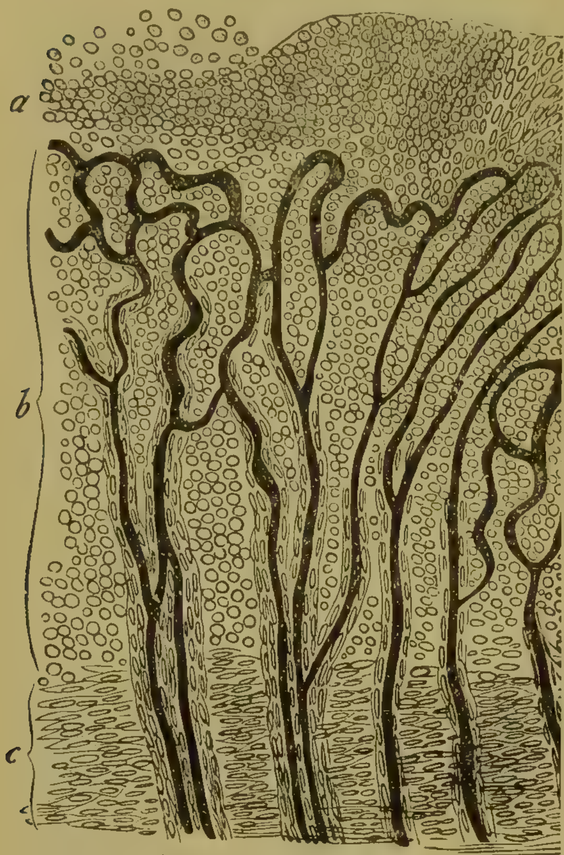
As I have already said, in order that any tissue may be assimilated it must first be digested. In the cases above mentioned the soluble ferment is secreted by the giant-cells at the point of irritation.

The juxtaposition of the secreting cells and the tissue to be resorbed is a matter of essential import. The ferment or fluid in question is not an exuded fluid of the blood; it is as truly a specialized fluid as are the secretions of the peptic glands of the stomach. The nature of the body to be resorbed has no more influence in the production of the secretions than have the various food-stuffs which are taken into the stomach over

the secretions of the stomachic glands. Resorbed and resorber must be in actual contact, as is seen in every instance where tissues are to be removed.

After normal circulation has been restored—which latter is absolutely necessary for the rebuilding of lost tissue—the process of inflammation ended, and the patient surviving, progressive metamorphosis follows. The wasted tissues are restored in whole or in part. If the loss sustained has not been too extensive, the new tissue will be like unto the old and will perform the same functions as its predecessor. On the other hand, if the lesion in the continuity of structure is very great, the loss is repaired by "scar-tissue," which never assumes healthy normal function.

FIG. 140.



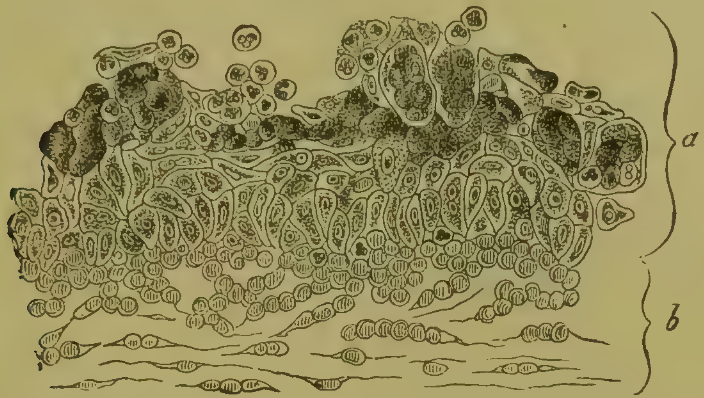
A Granulating Surface: *a*, layer of pus; *b*, granulation-tissue with loops of blood-vessels; *c*, commencing development of the granulation-tissue into a fibrillated structure (× 200).

III. *Inflammations of the Oral Mucous Membrane treated as Individual Members of a Class.*—1. *Catarrhal Stomatitis.*—Catarrhal stomatitis may be either acute or chronic. Acute catarrhal inflammation of the buccal mucous membrane begins as bright-red patches on the inside of the cheeks or at the angles of the mouth. These patches increase in size, and sometimes coalesce, so that the entire mucous membrane of the mouth may become involved. There is very little swelling, because the extent of connective tissue to become infiltrated is very limited. The mucous membrane of the mouth is at first dryer than normal, on account of a less quantity of mucus being secreted by the glands: this stage is followed by an excessive flow of mucus, which, being produced in too great quantity, is abnormal in quality, and is acrid and irritating to the mucous membrane. This in itself becomes a source of increased inflammation: the parts become more congested, the blood-vessels become involved and engorged with blood, the color of the mucous membrane changes and assumes a dark-red hue. The process of desquamation of epithelial cells increases, and the cells are found quite abundantly mixed with the mucus of the mouth. Consequent upon the engorgement of the vessels follows the exudation of white blood-corpuscles; in greater or less quantity these are present in every catarrhal inflammation of the mouth, and indicate the intensity and character of the inflammation.

In some instances the superficial cells are cast off faster than they are developed, in which case shallow ulcers appear. The breath is rarely

fetid in acute catarrhal stomatitis, and seldom does the process involve the substance of the tongue, although in some instances the tongue

FIG. 141.



Catarrhal Inflammation of the Conjunctiva: *a*, epithelium; *b*, infiltrated subepithelial connective tissue, showing the desquamation of the epithelium and the young elements within the epithelial cells.

becomes œdematous and the imprint of the teeth is seen on its sides. The whole surface of the mouth and tongue becomes coated with a white, viscid mucus. These changes are superficial, and do not present as structural alterations unless ulceration has supervened.

On making a post-mortem examination we find that the engorgement of the vessels has subsided and the œdema of the mucous membrane has disappeared; there are no pathological changes that would indicate that there had existed an acute catarrhal inflammation previous to death.

2. *Chronic Catarrhal Stomatitis.*—In chronic catarrhal inflammation of the mouth the stroma is involved and structural changes ensue. The connective tissue of the stroma is frequently infiltrated with the exudation from the vessels; the mucous membrane becomes indurated and thickened; it thus exerts a pressure upon the mucous glands, preventing the escape of their contents; they become encysted and present a granular appearance upon the surface of the mucous membrane. The papillæ of the tongue become swollen, although the substance of the tongue is less affected than it is in the acute form. The secretions of the mouth are disagreeable; sordes collect on the teeth.

Etiology.—When catarrhal inflammation occurs in children, it is generally of the acute form and is concomitant with and consequent upon the process of dentition. In adults stomatitis may result from the excessive use of tobacco or may be an extension of an inflammation resulting from the extraction of inferior third molars, to which the gums are very liable to become adherent. The sharp edges of decayed teeth sometimes act as mechanical irritants; the local lesion may result from constitutional derangement; the saliva may become extremely acrid in its reaction and excoriate the mouth; extremes of heat and cold may engender it. The specific effect of mercury presents itself in the mouth in a characteristic lesion on the edges of the gums around the teeth. Acute catarrhal stomatitis also accompanies the several forms of exanthemata: improper hygienic conditions and poor food may give rise to it.

Symptoms.—The symptoms are those ordinarily accompanying inflammation—viz. redness, heat, pain, and swelling. The pain is of a peculiarly smarting, burning nature, caused by the acrid secretions acting directly on the denuded papillæ. There is some fever, anorexia, diarrhœa with flatulence; in the more severe forms vomiting sometimes ensues. If the catarrh extends to the fauces, there is difficulty in swallowing; the sense of taste is often affected, and there is a general feeling of malaise; ptyalism usually accompanies it, and the acrid secretions excoriate the corners of the mouth. Sordes composed of desquamated epithelial cells, pus, and mucus collect on the teeth, the tongue becomes furred: the patients in the worst forms of stomatitis are continually trying to relieve themselves of the disagreeable feeling by hawking and spitting.

Prognosis.—As a rule, the acute form lasts but a few days. Chronic catarrhal stomatitis is more persistent, but with the removal of the cause of irritation it generally becomes amenable to local treatment. This should consist of alkaline washes: these not answering, a dilute solution, one grain to the ounce, of zinc chloride or silver nitrate should be resorted to. Phenate of soda comes in very happily as a wash or used in the form of spray to overcome the fetid odor of the breath. The writer has had very excellent results in the treatment of chronic cases by using the following recipe, the preparation to be sprayed over the surfaces several times daily:

℞. Acidi carbolici, ʒj;
Olei gaultheriæ, ʒij;
Olei menthæ piperitæ, ʒiij. M.

Sig. Use as spray.

It is slightly stimulating and antiseptic: it should not be used in the acute form of the disease. Dilute cologne-water has been recommended.

3. *Aphthous Stomatitis.*—Aphthous stomatitis, or canker sore mouth, makes its appearance on the mucous membrane of the mouth, first as small vesicle-shaped elevations: these are generally situated either on the inner surface of the lower lip near the frænum of the tongue or on the inside of the cheeks; sometimes they are found on the tongue. The vesicle is whitish and surrounded by an inflamed zone about its base; after the vesicle ruptures it presents an irregular gray surface, which heals slowly, the process sometimes requiring a week or more. The ulcers are shallow, and seldom involve the stroma of the mucous membrane: they are painful, but produce little or no constitutional derangement. This disease in adults is confined to no special condition in life: it is apt to occur in women at or about the menstrual period, especially if there is any interference with the normal flow. It is also present during pregnancy and lactation. The mucous membrane may become thickly studded with vesicles, which may join, and thus become confluent. The confluent form is more prevalent in infants than in adults.

If the conditions are favorable, vegetable fungi may attach themselves to the edges of the ulcers. Ptyalism is present in nearly all cases. The intestinal disturbance, if any exists, may be corrected by small doses of rhubarb or citrate of magnesia: a local application of nitric acid, lightly applied on a sharpened stick, will cause the ulcer to heal very

quickly; potassium chlorate, held on the ulcer, will also be remedial, and it is not so severe as the nitric acid, although the acid is the more efficacious. Tonics are indicated, such as tinctura ferri chloridi, quininæ sulphas, and other vegetable bitters.

4. *Thrush complicating Aphthous Stomatitis.*—This is a form of stomatitis in which, in addition to the ordinary conditions, are found vegetable fungi. According to Grawitz, "The mycelium found in thrush belongs most generally to the yeast family, probably the Micoderma vini, which he has proven capable of cultivation in mucous membranes. The patches consist of tortuous often branching cells or filaments, united end to end and distinctly constricted where they join. The filaments end in roundish cells or spores; these form heaps in the epithelium."[1]

Then, again, the mould fungi, Oidium albicans, is found developing in the mouth in a manner similar to the Micoderma vini. These two fungi very much resemble each other. The filaments in the Oidium albicans are slenderer than the yeast filaments, and are not so distinctly jointed. These two forms are said, by good authority, to be capable of cultivation, the one into the other; others say that spores of both species are present: under one condition one develops; change the condition and the second will be produced, while the first disappears.

The subepithelial tissue is seldom invaded, except when the *vis vitæ* has been very considerably lowered by constitutional or local disease. These fungi are not to be regarded as the specific cause of thrush. These vegetable parasites develop best in acid secretions. We have seen that in both forms of stomatitis there is an abnormal secretion of mucus: normal mucus is alkaline, but mucus produced in excess is acid. Thrush does not appear in healthy mouths; it is only found when the secretions are vitiated, and then only by the addition of the spores of some vegetable parasite when all the conditions are favorable for its development. As all the conditions are not always present at the same time, so we do not find thrush developing in all forms of stomatitis, neither do we find the spores present at all times when the other conditions are favorable.

The disease is epidemic during the spring and fall. It sometimes becomes endemic in hospital wards, infant asylums, and even in private houses located in damp localities. When the fungus does find a home in the already inflamed tissue, it increases the inflammatory action by the further decay that it sets up. In thrush complicating aphthous stomatitis small white flocculent patches appear on the surface of the mucous membrane. If the case is watched, the patches are seen to grow, and finally coalesce. If one of the spots be scraped off and examined under the microscope, it will be found to be some form of vegetable parasite, most generally the Oidium albicans, which is sometimes accompanied by the development of the constant inhabitant of the mouth, the Leptothrix buccalis, although the latter is most commonly found on the cervical margin of the gums around and between the teeth, where there is a constant acid condition. The mycelial threads of these vegetable parasites burrow into the epithelium, separating the

[1] *Virchow's Arch.*, vol. lxx.

cells and holding them in its meshes. The disease progressing, the sub-epithelial tissue or stroma may become involved: the confluent patches fall off and cover the tongue with a white coating, which if examined will be found to consist of mucus, epithelial cells, pus, and spores, all held together by the filaments of the parasite. The fungus growth may extend to the nasal passages and the pharynx, or it may confine itself entirely to the tongue; it has been found throughout the alimentary canal. The disease does not attack healthy persons, but confines itself to emaciated children and persons in the last stages of phthisis: it is also found accompanying or following typhus and malarial fever.

Want of care of nursing-bottles is one of the principal causes of the disease in children. In its first stages in children the mouth becomes

FIG. 142.

Oidium albicans, from the Mouth in a Case of Thrush.

hot and painful; the child partakes eagerly of cold drinks—will not allow the mouth to be touched, thereby calling attention to the local lesion, as also does the salivation which is always present. There is also marked gastro-intestinal disturbance: vomiting and diarrhœa are frequent concomitants. The stools are greenish, and so acrid that they excoriate the parts with which they come in contact. In adults ptyalism and painful deglutition follow a dry, hot, and painful condition of the mouth. The presence of the fungus establishes the diagnosis. Treatment consists in neutralizing the acid condition of the secretions: this will destroy the fungi. To start the secretions and regulate the bowels the following combination is recommended:

℞. Infusi rhei, ℥iij;
Potassii bicarbonatis, ʒj;
Tincturæ cinnamomi, ʒij;
Syrupi simplicis, ʒvj. M.

Sig. A teaspoonful every three hours for an adult.

A grain of sulphate of quinine every three hours will improve the

condition of infants. For adults the best tonic treatment consists in the well-known combination—

℞. Tincturæ ferri chloridi, ℥j;
Quininæ sulphatis, ʒj. M.

Sig. Fifteen drops in water every three hours.

A local wash composed of one grain of potassium permanganate to the ounce of water makes an excellent antiseptic, oxidizing, and deodorizing agent.

The following tonic formulæ are very highly recommended by Dr. Müller of Cross Plains, Wis.: Basham's iron mixture, with the addition of fractional doses of strychnia, will be found very admirable in its effects. There are so many indifferent recipes for making this celebrated mixture that I shall here give the one which seems to me to be the best:

℞. Tinct. ferri chloridi, fʒiij;
Acid. acetic. diluti, f℥ss;
Liq. ammoniæ acetat. f℥iijss;
Curacoæ,
Syr. simplicis, *āā*, f℥j;
Aquam, ad f℥viij. M.

Sig. Dose, one tablespoonful after each meal.

The following formula makes another very elegant and generally useful preparation of iron:

℞. Tinct. ferri chloridi, fʒij;
Acid. phosphorici diluti, fʒiij;
Spt. limonis, fʒj;
Syr. simplicis, f℥ijss;
Aquam, ad f℥vj. M.

Sig. One tablespoonful after each meal.

The dilute phosphoric acid is added both because it is a valuable nerve tonic, and because it has the property of disguising the styptic taste of the iron—so much so that children readily take this mixture.

Another preparation is a valuable alterative tonic, for the formula of which Dr. M. is indebted to his friend Dr. A. H. Trousseau:

℞. Hydrarg. chloridi corrosivi, gr. i–ij;
Liq. arsenici chloridi, f℥j;
Tinct. ferri chloridi,
Acid. hydrochlorici dil. *āā*, fʒiv;
Syrupi, f℥iij;
Aquam, ad f℥vj. M.

Sig. One dessertspoonful in a wineglassful of water after each meal.

Anæmic and chronic patients will fatten and thrive wonderfully on this mixture—the mixture of four chlorides. It should not be given for a longer period than two weeks at a time.[1]

Alimentation of Infants Affected with Thrush.—When new-born children affected with thrush refuse to take the breast or the bottle, Dr. Wiederhofer[2] advises the pouring of milk by means of a funnel through the nasal fossæ. This mode of alimentation is not difficult. When the milk enters the pharynx, it provokes reflex movements of deglutition and is propelled into the stomach. The author has been enabled by this means to nourish infants for three and four weeks in succession. The same procedure is useful

[1] *Medical Age.* [2] *Journal de Médecine de Bordeaux.*

in children born before term in whom there are no spontaneous movements of deglutition.[1]

5. *Ulcerative Stomatitis, or Noma.*—Ulcerative stomatitis in its initial stage is a lesion of the gums: it may, however, involve the cheeks. It is more or less superficial, and belongs to the croupous form of inflammation. The gums are more congested than in the other forms of stomatitis, and present a bluish, tumefied appearance. The surface is coated with an exudation which is composed of fibrin, pus, epithelial cells, and fungi or micrococci, or both.

The membrane, for such it is, presents a grayish-white appearance: it, however, soon breaks down, as does the underlying tissue. The compression of the vessels by the accumulation of the pus and fibrin in the stroma causes a stagnation of the blood in the vessels; the exudation ceases; the mucous membrane dies, degenerates, and sloughs off. This process of coagulation necrosis may extend to the cheeks. The

FIG. 143.

Croupous (false) Membrane from the Trachea (× 250): *a*, section through false membrane; *b*, upper layer of mucous membrane infiltrated with pus-cells, *d*; *c*, fibres and granules of fibrin; *d*, pus-cells.

gums are sometimes destroyed; the teeth become loose and drop out, and in extreme cases the maxillæ become involved and exfoliate.

Ulcerative stomatitis occurs in children from one to ten years of age: it is not contagious, but is a disease of the very poorest classes, who live in damp, unhealthy places, where the hygienic surroundings are of the very worst character. It is a very rare disease, and occurs only in those who are poorly nourished.

Symptoms.—At the onset the mouth is hot and painful, as in the other forms of stomatitis: this condition is followed by salivation; the breath is very offensive, the lips are swollen, and the mouth is held persistently open. The submaxillary glands are swollen and tender. The prognosis, as regards life, is good: as a rule, it is not considered a very dangerous disease. The treatment is constitutional—oleum morrhuæ and syrupus calcii lactophosphatis or tinctura ferri chloridi and quininæ sulphas. Local washes, composed of dilute zinc chloride, silver nitrate, or carbolic acid, diluted, will be found efficacious to disinfect the degenerating tissue. Plenty of fresh air and a nourishing diet will complete the cure; but as the parents are seldom able to comply

[1] *Medical News.*

with the latter part of the advised treatment, the disease is very apt to be tedious.

There is another form of ulceration found in the mouth, due to syphilitic disease, which we will consider here.

Syphilitic Ulcers of the Tongue and of the Mucous Membrane of Other Portions of the Mouth.—As a rule, syphilitic ulcers of the mouth are secondary, resulting from constitutional syphilis.

Initial lesions are rare, and are generally found in cases where persons are addicted to unnatural practices, or the result of kissing where the lesion presents itself upon the lips. The sore is usually superficial. It is rarely irritating, and very little pus is discharged: occasionally, however, the sore is phagedænic in character. The glands of the neck are often enlarged as a sequela. The location of the ulcer is usually found on the tip or side of the tongue or upon the tonsil.

Secondary ulcers may be divided into two classes: 1. Those resulting from abrasions or injuries, or those which come from the breaking down of mucous patches, due to abrasion caused by contact with the teeth. These are confined to the sides of the tongue. 2. Secondary ulcers of the second class first make their appearance upon the dorsum of the tongue, tonsils, or pharynx. It is very difficult to make a differential diagnosis between the two, as they are seldom seen in the first stages of their inception. The disease has usually progressed to a greater or less extent before the patient presents himself for treatment. The absence of the signs of other diseases is more to be depended upon than are the distinctive features of syphilis. In the absence of well-marked constitutional syphilis the diagnosis may sometimes be reached by the amenability of the ulcers to specific medication. In fact, about the only means of differentiating between the syphilitic ulcers of the class under consideration and epithelioma, other than by the use of the microscope, is found in medication, a syphilitic ulcer answering more or less readily to specific medication. As a general rule, however, in secondary ulcers, some indication of constitutional syphilis will be found. Syphilitic iritis or the scars of the original sore upon the penis may yet remain, and even present more or less induration. In the case of women examination will show similar indications in the vagina or around the anus, or upon the tibia nodes may be found. The surest diagnosis is made by specific medication, which I should advise in every case where doubt or obscurity exists.

Treatment.—Treatment in these secondary cases is usually quickly successful. It should consist of local and constitutional remedies. In some instances these ulcers answer to local treatment alone; but when such is the case doubt may be entertained regarding their specific nature. When an angry excoriation presents itself upon the sides of the tongue, the teeth should be first examined and broken or ragged edges smoothed off. If the ulcer does not readily improve, then a solution of ten grains of chromic acid to the ounce of water should be applied three times daily with a camel's-hair brush. This failing, mercurial treatment should be employed, and imperative directions given the patient to abstain from smoking or the use of alcoholic drinks, which will irritate the ulcer.

The ulcers of *tertiary* syphilis are of a more serious nature, and will seldom come under treatment by the dental practitioner; hence they will not be considered here.

The following citations of well-authenticated cases will add materially to the understanding of the subject:

Syphilitic Ulceration of the Tongue—Chromic Acid.—Dr. R. A. Stirling, L. R. C. S., surgeon to the Melbourne Hospital, reports the following: Miss K——, æt. twenty-two, domestic, contracted a chancre eighteen months ago. She has been constantly under treatment. She came to me February 1, 1885, suffering from a large ragged ulcer on each sublateral surface of the tongue. These ulcers appeared three months previously, and are very painful during swallowing. There were two or three excoriations on the lips. The throat bears traces of having at one time been much affected. There is a papular syphilide on the backs of the arms only. I painted the glossal ulcers with chromic-acid solution (gr. x–℥j), and also the excoriations of the lips.

Feb. 3d. The sores on the under surface of the tongue are all but healed. The acid again applied.

Feb. 5th. She is now quite rid of her mouth troubles.[1]

Gummata of the Tongue.—Particulars of a case of this kind were read by Dr. Celso Pellizzari before the Medical Society of Siena.[2] The patient was a man, aged sixty-five, who in 1840 (forty-three years before he came under observation) had had a sore on the penis, followed by pains in the head and bones, a rash on the skin, and moist patches in the mouth. He was treated with iodine and mercury for about a month. He married in 1855, and became the father of four healthy children. He had always enjoyed good health until a month before he came to Dr. Pellizzari (November, 1883), when he noticed a nodule in the left anterior half of his tongue. Other nodules afterward appeared, and these subsequently became fused into one elongated swelling. At the same time two other nodules appeared in the dorsum linguæ. The lumps were hard at first, but gradually softened and ulcerated. On examination of the man, who appeared vigorous and healthy, the apex of the tongue was found to be indurated, and there were two scooped-out ulcers on the upper surface. On the left side of the tongue there was a third ulcer. There was no glandular enlargement. Small doses of perchloride of mercury and iodide of sodium were prescribed three times daily. In a week the ulcers were half healed and the infiltration of the tip had greatly diminished. After a month's treatment the patient wrote to say he was well.[3]

Syphilis and Carcinoma.—The relations between these two affections have been studied chiefly by Verneuil, but in a recent article Dr. Ozenne[4] treats at some length of the characteristics of this hybrid condition as it is observed in the buccal cavity. The paper has to do only with cancer as associated with the tertiary manifestations of syphilis, for hitherto the disease has not been observed in connection with the earlier syphilitic lesions. The hybrid affection is seen under three forms: the sclero-cancerous, the gummo-cancerous, and the sclero-gummo-cancerous. In the first of these forms the cancerous tumor usually appears first, though sometimes the syphilitic lesion precedes, and then suddenly we have presented a mixture of the carcinomatous neo-formation with the alterations of sclerotic glossitis. The

[1] *Australasian Medical Journal.*
[2] *Giornale Ital. delle Mal. Ven. e della Pelle,* fasc. i., 1884.
[3] *London Medical Record.*
[4] *Archives méd. Belges.*

tongue is increased in volume, and at a certain point the cancerous tumor is seen as an irregular induration of variable size, either projecting above the surface if the neoplasm is superficial, or under the form of an elastic, resisting submucous tumor, with indurated base, if the epithelioma is of the interstitial variety. Alongside of this part invaded by the cancer are seen the indurated lesions of the syphilitic affection, over which the mucous membrane appears smooth, glistening, and pale. More frequently, however, we have a dermo-parenchymatous glossitis, the induration of which, instead of being lamellated, is diffuse and deep, and gives to the finger a peculiar dry, hard feeling. In the gummo-cancerous form the two diseases are so blended together that the characters of either are almost wholly lost. There is a deep ulcer, the base of which is indurated as in cancer, but whose edges are not sharply cut, and it does not bleed, as does the cancerous ulceration. The third form is still more complex. Gumma, carcinoma, and dermo-parenchymatous sclerosis are associated together in variable proportions, sometimes one or the other being the most distinct, and sometimes all being blended together in indistinguishable confusion. As regards the functional symptoms of this hybrid affection, they are less severe usually than when either one of the lesions occurs separately. Thus hemorrhage is rarely seen, and the pain which accompanies cancer is often wanting. The prognosis, however, is, unfortunately, always that of carcinoma. Yet treatment with the iodides forms a sure means of making a differential diagnosis.

Diagnosis of Syphilitic Chancre of the Tonsil.—In a long paper published in the *Archives Gén. de Médecine*, January and March, 1884, M. Le Gendre reports two cases of this kind observed by himself, and quotes eleven others from various sources. From an examination of these cases the author draws the following conclusions as regards diagnosis: Diphtheritic angina, gangrenous angina, epithelioma, and ulcerated gumma are the affections most likely to be confounded with the initial lesion of syphilis, which, when situated on the tonsil, may present very variable characters. Induration may be felt for, but in the majority of cases this will not be characteristic. Adenopathy is a most important sign, but it occurs also in epithelioma and in diphtheria: the former disease, however, is often attended by more constant as well as by lancinating pains. The initial lesion of syphilis gives little pain when the patient is not swallowing. In cancer the glands are moderate in size and painful on pressure. In primary syphilis there is one large gland, which is very hard, indolent, and only slightly movable, surrounded by other small glands. The general condition of the patient must also be considered. The limitation of the affection to one side of the throat is very much against diphtheria, as also is the length of time the patient has usually suffered before advice is sought. The surface of the syphilitic ulcer also is easily cleansed, and the detritus is pultaceous and friable, rather than pseudo-membranous and tough. In the case of the initial lesion there is rather extensive surrounding redness and swelling. In gumma these signs are usually absent. Gumma also does not cause so much trouble in swallowing, nor so much salivation, as the initial lesion. M. Brouardel had a case of tubercular ulceration of the tonsil in which there was a temporary doubt as to primary syphilis. The soft chancre appears never to have been observed on the tonsil. Of the thirteen cases of primary syphilis of the tonsil dealt with in his paper, seven were men and six were women. One of the women had contracted the disease through sucking the bottle of her syphilitic grandchild, and another by kissing her grandchild, which had mucous patches on its lips. The author agrees with M. Diday that kissing

is the most frequent mode of contagion, and that this occurs by suction of the contagious material into the large open lacunæ of the tonsil.[1]

Chancre of the Tonsil.—Dr. Robert W. Taylor read a paper on this subject at the New York Academy of Medicine.

Having explained that the lesion of the tonsil of which he wished to speak was true chancre alone (to the exclusion of chancroid), he stated that it was not so rare as had hitherto been supposed. As to its origin, chancre of the tonsil might be due to kissing, the contact of pencils, glasses, bottles, and perhaps cigars, with the mucous membrane of the mouth, and also to depraved and unnatural sexual contact, which, he regretted to say, had become alarmingly frequent in the community. In November, 1882, he was asked by Dr. Charles McBurney to come to Bellevue Hospital to see a boy nine years of age in his wards who was suffering from a fracture of the tibia, and who, since he had been under treatment at the hospital, had developed a well-marked attack of acute secondary syphilis, with undeniable chancre of the tonsils. Dr. Taylor then read the full history of the case as detailed by the house-surgeon at Bellevue, from which it appeared that the syphilide (roseola), the true nature of which was not immediately recognized, was first noticed on the boy's chest on the 12th of November. On the 16th the chancre was discovered on the left tonsil, and anti-syphilitic treatment was commenced. The tonsil was swollen and covered with a white membrane, and the cervical glands in the vicinity were much enlarged. The boy confessed to unnatural practices.

In June, 1882, a young woman of promiscuous habits, who was under his care at the time for other troubles, complained to Dr. Taylor that she had a slight sore throat. On making an examination he found that the left tonsil (both tonsils were chronically enlarged) was somewhat red, though it was not hard, and the ganglia were not perceptibly enlarged. Under the circumstances he ordered a simple gargle and awaited events. The patient then went out of town for nearly a fortnight, and when she returned he found the left tonsil was much swollen and indurated, while the ganglia were enlarged and matted together. Three weeks later the inguinal glands became implicated and a roseolous syphilide appeared. The chancre on the tonsil was found to have originated from unnatural practices.

Dr. Taylor next referred to four other cases which he had either seen himself or which had come within his immediate knowledge. The first he had had an opportunity of seeing through the courtesy of Dr. George H. Fox, and it was in a man who exhibited the most disgusting depravity in speaking of the practices to which he was addicted and through which he became infected with chancre of the tonsil. The second was that of a young man who had a chancre of the left tonsil and at the time was suffering from a tubercular syphilide. The third case was one of great interest, for the history of which he was indebted to Dr. Edward Wigglesworth of Boston. It occurred in a medical student who contracted chancre of the right tonsil while placing his mouth in contact with that of an asphyxiated newly-born infant whom he was endeavoring to resuscitate, which was followed by well-marked constitutional syphilis. The fourth and last case, originating from indulgence in beastly practices, was related to Dr. Taylor with great minuteness by the late Dr. F. J. Bumstead, so that he could thus present six well-authenticated cases of chancre of the tonsils, all of which were followed by constitutional syphilis, and from all of which all other sources of infection were eliminated. The other cases that had thus far

[1] *London Medical Record.*

been reported were two by a Russian writer, one by Spillman, and four occurring under the observation of Fournier.

Dr. Taylor then spoke of the clinical history of chancre of the tonsil. The first appearances were redness and swelling without perceptible adenitis. The severity of the symptoms then increased, and induration and ulceration were noticed, while a grayish-white coating might be irregularly spread over the ulceration. The differential diagnosis had to be made between chancre on the one hand and mucous patches, syphilitic sclerosis, or epithelial cancer on the other. In the syphilitic lesions referred to the trouble would not be so completely confined to one side, and there would be by no means such marked adenopathy, while the history would, as a rule, throw light on the matter.

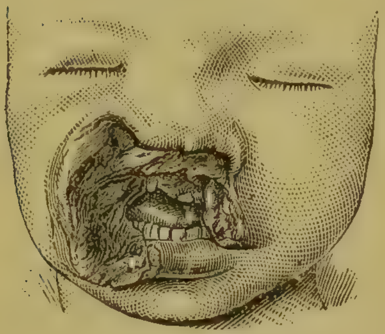
In conclusion, Dr. Taylor said that the following points would render the diagnosis of chancre of the tonsil practically certain: First, the details of infection, whether from kissing, from contact of such articles as has been referred to, or from indulgence in bestial practices. Second, the slow, insidious development of the lesion, which runs a subacute course. Third, its unilateral position. Fourth, difficulty of deglutition, and even pain referred to one side. Fifth, the special implication of the preauricular gland. Sixth, much less induration of the glands in general—particularly those at a distance from the throat—than is usually met with in connection with ordinary chancre.[1]

6. *Gangrenous Stomatitis, or Cancrum Oris.*—This is a most formidable disease of childhood. It is exceedingly rare, and is essentially a disease of the poorer classes: it is only met with in feeble, ill-fed children whose *vis vitæ* is at the very lowest ebb. It may be brought on by mercurialization. Some authors on account of its rapid course claim that it is caused by a specific virus. It is a constitutional disease, and the local lesion begins in the vessels supplying the part. The infiltration of pus and fibrin into the cellular tissue of the cheeks proceeds with great rapidity, until they become thickened and indurated, and the skin externally and the mucous membrane internally present a tense, glistening appearance. The exudation is sometimes absent, and the process is preceded by an anæmic condition, during which the tissues present a bloodless appearance: this is followed by gangrene, without the usual precursory inflammation having set in, and is no doubt caused by the plugging of some of the larger vessels supplying the parts by an embolus or a colony of bacteria. The process is similar to the one studied in a previous section, where the ligature was left around the tongue until gangrene set in: this form is of very rare occurrence. As a rule, however, from the nature of the disease we infer that it is a process of coagulative necrosis. Some deleterious agent—or micro-organism perhaps—is carried to the part by the vessels which are themselves first affected. This is followed by intense inflammation of the surrounding cellular tissue, which is succeeded by a copious exudation: the white blood-cells are dissolved by the exuded fluid, and coagulation ensues. That some such process takes place in cancrum oris is evidenced by the brawny hardness presented by the tissues: it is not a simple œdematous infiltration of the cellular tissues of the cheeks. The mucous membrane of the cheek at the point where the tissues will first break down presents a

[1] *Philadelphia Medical News.*

dusky appearance, surrounded by a red inflammatory zone; the dark portion soon sloughs, and the ulcer thus formed presents a deep, ragged, irregular border, covered by a dark ashy-brown colored deposit. The ulceration extends, and the solid constituents of the tissues disappear in rapid succession until the walls of the oral cavity are perforated, when a deep, irregular surface will present, from which a semifluid dark-gray or grayish-yellow mass is constantly discharging. The disease extends by ulceration and subsequent sloughing, until the soft parts may all become involved: bone resists longer than cellular tissue.

FIG. 144.



Cancrum Oris.

In the process of putrid decomposition micro-organisms are always present; in the later stages mould fungi find this form of disease a suitable habitation. One of the products of decomposition is sulphuretted hydrogen: this gives to the breath a peculiar fetid odor. Death, which occurs in nine out of ten cases, may result from several causes: pyæmia may set in; the child suffers very little; it becomes drowsy and dies in a comatose condition; some of the large vessels may become eroded and perforated, when death results from hemorrhage. The patient usually dies from exhaustion. Treatment consists in the use of tonics, good food, milk, eggs, and beef-tea: when food cannot be given by the mouth, it may be administered *per rectum* in the form of enemata. Tonics should be given, and the strength of the child kept up if possible. Oleum morrhuæ should be rubbed over the surface of the body. The diseased parts should be thoroughly cleansed and sprayed with chlorinized or carbolized water. Silver nitrate or strong nitric acid should be applied to the edges of ulcers to destroy the diseased tissue and induce healthy granulations. Regeneration of lost tissue is from the migrating white blood-cells. New blood-vessels are developed to supply the forming tissue with nourishment. Epithelium develops epithelium; muscular tissue is produced from pre-existing muscle-cells; and a remnant of periosteum forms new bone, each after its kind.

GLOSSITIS.

Glossitis signifies inflammation of the tongue. The same systemic conditions that give rise to catarrhal or aphthous stomatitis may find their expression on the tongue. The worst case of thrush I ever saw was confined to the tongue alone, the mucous membrane of the mouth remaining comparatively healthy. The treatment of the above forms of glossitis is similar to the treatment laid down for the same forms of stomatitis, the character of the lesion differing in no way from the latter except in location.

Symptomatic glossitis is very common. The tongue is the bulletin-board on which we may read the indications of the general system. It is the indicator to the condition of the stomach, liver, and blood. "A white-coated tongue denotes febrile disturbance; a brown, moist tongue,

indigestion; a brown, dry tongue, depression, blood-poisoning, typhoid fever; a red, moist tongue, feebleness, exhaustion; a red, dry tongue, inflammatory fever; a red, glazed tongue, general fever; a tremulous, moist, and flabby tongue, with blue appearance, tertiary syphilis." A moist, flabby tongue, with the imprint of the teeth in its sides, indicates general anæmia; a pointed tongue shows intestinal derangement; a yellow, furred tongue indicates bilious disorder; a moist tongue is a good indication in sickness; while a dry tongue represents the converse condition. Thus we read the refinements of the indications, plain or otherwise to us according to our ability to recognize the several conditions.

Phlegmonous Glossitis.—This form of inflammation is located in the substance of the tongue. It may be either acute or chronic. As a rule, such inflammation is due to a general lesion, in which the blood-vessels are involved. The tongue becomes somewhat swollen and hyperæmic, and redder than normal. The hyperæmia may rapidly subside, or the tongue may become markedly œdematous and enlarged, the different conditions being dependent entirely upon the gravity of the disturbance to the equilibrium of the circulation. If the hyperæmia continues for any great length of time, pathological cellular development is liable to ensue and the tongue assume an hypertrophied condition, or small abscesses may form. The surface of the tongue is covered with a thick coating of exuded serum.

Etiology.—These several forms of glossitis may arise from general systemic derangement, most generally mercurialization, or may come from local irritants—burns, scalds, caustics, decayed teeth, etc.

When thrush makes its home on the tongue there is almost always more or less enlargement: this is partly due to the "anæmic tongue" in the first place, and secondly to the inflammation the fungus sets up.

Symptoms.—Accompanying the development of the fungus there is profuse salivation: this is apt to be a marked symptom in all the forms of phlegmonous glossitis. The mouth is held persistently open; the tongue is very tender; the glands of the mouth are apt to sympathize and become inflamed. The swollen tongue interferes markedly with the act of respiration: the patient is unable to take any solid food, and altogether he is in a very deplorable condition, although not as dangerous as would at first seem.

The cases here cited are of especial interest on account of their rarity:

Case of Black Tongue.—G. T. Broatch, M. B., C. M. Edin., Aylesbury, writes: The following case of black tongue may be interesting, presenting, as it does, many points of resemblance to that recorded in the *Journal* of March 29th. The patient is a man aged sixty, a painter and glazier by trade, but on account of ill-health has not done any work for seven years. Shortly after he commenced his apprenticeship he was attacked with lead colic, and the blue line characteristic of lead-poisoning appeared on his gums, and remained for about twelve months. He has never enjoyed robust health, and at present suffers from ulcers on his legs, which have existed for the last thirty years.

On examination of the tongue the blackness is seen to be in the form of a circular patch, about an inch in diameter, situated at the posterior third

of the dorsum. The greater part of it is of a deep-black color, while at the margin it is lighter, being brownish; and surrounding this for about half an inch there is a whitish tinge. Behind the coloration are a number of light-colored nodules in the position of the circumvallate papillæ. The other parts of the tongue, except being slightly fissured, are normal. Upon stroking the patch with the finger from before backward it feels soft and smooth; while on reversing the motion it feels roughish, this being caused by the finger passing over what looks like a mass of black hairs. The discoloration is entirely composed of these black filaments, some of them of considerable length, with shorter ones intermixed. They can be detached easily with dressing-forceps, bringing along with them a portion of the subjacent tissue, which is light in color. The blackness commenced about two years ago, the patient feeling, as he describes it, as if his tongue were too large for his mouth; and on examining it he found a small discolored spot, which has gone on extending ever since. He has no pain in the tongue nor any diminution in his sense of taste.

On microscopical examination of one of the filaments it is seen to be composed of epithelial cells of a brown color closely packed and overlapping one another. In some cases the centre of the filament is very dark, with a lighter margin, and in other cases it is the reverse. When the latter condition occurs there appears to be a tendency for it to split down the centre. On examination, from the apex of the thread downward the color gradually becomes less, till at the point where it springs from the tongue no staining of the cells can be detected. These filaments appear to be, as stated in the article by Mr. Stoker, the fringes of the papillæ greatly hypertrophied and their cells stained of a brown color.[1]

"*The Circinate Eruption of the Tongue called 'État lichenoide' by Gubler, and 'La Syphilis desquamative de la Langue' by Parrott.*"—M. A. Veeder, M.D., Lyons, New York, U.S.A., writes: The article in *The Lancet* of May 10th under the above heading has interested me from the fact that it has been my fortune to meet with several cases of the kind recently. In none of them was there a history of syphilis, whilst in all there appeared to be a tendency to disorder of the stomach or bowels. In two adults at one period of the disease there was muco-enteritis lasting for weeks. In the case of a lady over forty pears of age, who "had noticed the spots on her tongue at times for a long while," there were attacks of sickness at the stomach, accompanied by the vomiting of mucus resembling the white of an egg. After trying many plans of treatment without decisive result, I happened to give salicin for another purpose, and there was such immediate improvement in the condition of the tongue that I began to use the remedy specially with reference to it. My plan is to evacuate the bowels pretty thoroughly by means of a saline cathartic rich in chlorides—as, for instance, Friedrichshall water—given in the morning before breakfast, and then to give full doses of salicin for several days. This cuts short the eruption promptly, and when used repeatedly during the attacks lengthens the intervals of recurrence, until it has seemed to me that a perfect cure has been effected, there having been no appearance of the disease for many months.[2]

Lepra Affecting the Tongue.—Campana reports a case in the *Giorn. Ital. della Malattie Veneree e della Pelle*, fasc. v. an. viii., of a youth aged fifteen, born of leprous parents, who for five years had suffered from maculo-nodular leprous eruptions of the skin of the face and limbs. The same eruption appeared on the tongue, and was there characterized by a group of little papilliform tumors, forming collectively an oval patch of the size of a half-

[1] *British Medical Journal.* [2] *London Lancet.*

penny, slightly raised, with a knotty and villous surface. The little tumors varied in size from a lentil to a hempseed; some were conical, others rounded: they were rose-colored and painless. A small bit was taken from the apex of one of them and hardened in absolute alcohol: sections showed numerous characteristic bacilli lepræ collected in the leucocytoid and giant-cells. The author concludes that lepra may give rise to neoplasms very similar to those of acuminate condylomata, in the same way as syphilis and tuberculosis.[1]

Treatment.—Treatment should at first be directed toward getting the secretory system in an active condition. Potassii acetas et tinctura rhei should be given; quininæ sulphas and oleum morrhuæ will strengthen the patient. Ice should be applied locally. In the event of suffocation becoming imminent, free incisions should be made into the tongue; these not affording relief, tracheotomy should be performed at once. The following interesting cases have been reported:

Macroglossa Treated by Paquelin's Cautery.—Helferich in 1879 employed ignipuncture with successful results in the treatment of macroglossa, and Dr. Weizsäcker relates an equally successful case which occurred in Brun's clinic at Tübingen. The greatly enlarged tongue of a girl five years of age projected constantly out of the mouth and greatly embarrassed respiration. Fourteen punctures were made with a Paquelin from above downward at about a centimeter from each other, and five in a transverse direction, without a drop of blood being lost. On the third day secondary hemorrhage occurred from the intercommunication of three of the punctures, but this was arrested by chloride of iron. The tongue gradually diminished in size, was withdrawn within the mouth, and all embarrassment of respiration ceased.[2]

Exfoliative Marginal Glossitis.—This is the name given by M. Fournier[3] to a peculiar and relatively rare inflammation of the tongue well described in a monograph recently published by M. G. Lemonnier. This form of glossitis is found most frequently in children, but may be observed at an advanced age. The causes are obscure. It has been considered as a syphilide (Parrott), but the relation is far from constant, and the same may be said of dyspepsia and malnutrition. Some of M. Lemonnier's patients had made an extensive use of tobacco or of alcohol; others had suffered from nervous diseases, rheumatism, or herpes. The three characteristic symptoms of the affection are—an irregular and sinuous patch of superficial inflammation and desquamation; a raised margin of whitish or grayish color surrounding the diseased part; a tendency to migration, causing the lesion to change its form and seat very rapidly. It is either unilateral or bilateral, and is never accompanied by pain, so that it may remain for a long time undetected. It has often been confounded with the glossitis of smokers, cachectic glossitis, and some forms of mucous tubercle. Cauterization has no beneficial effect. The best treatment consists in the avoidance of irritating food and drink, and in the use of soothing applications or pulverizations.[4]

Teeth causing Diseases of the Tongue.—Dr. Paul Berger[5] draws attention to the frequent extreme difficulty of diagnosing certain ulcers of the tongue. He recounts two cases wherein every sign of cancer was present: ulceration,

[1] *London Medical Record.*
[2] *Medical and Surgical Reporter.*
[3] *Journ. de Méd. Prat.*
[4] *London Medical Record.*
[5] *La France méd.*

induration, bleeding surface, and glandular involvement—a group of signs which made him quite sure that he had to deal with epitheliomata. In each case, however, the extraction of an irritating tooth cured the ulcers. The very practical lesson is hence derived that no matter how typical of cancer a diseased tongue may be, if there be a jagged or irregular tooth opposite no opinion should be given until a week or two after its extraction. I may add that during such interval it can likewise do no harm to give iodide of potassium as a diagnostic aid. I once had a case which an incautious physician had pronounced epithelioma of the tongue, and which certainly looked in every way like one, but which yielded to the iodide. The patient denied syphilis.[1]

Obstinate Ulcer of the Tongue in a Child.—Dr. Kemper of Muncie, Ind., reports a case where he became satisfied the ulcer was a result of the tongue gliding over the lower central incisors—the only teeth in the lower jaw—during the act of nursing, and so a constant irritation was kept up. He suggested weaning the babe, age twelve months, and the ulcer healed without any other treatment in about two weeks.[2]

Acute Glossitis—Incision—Recovery.—Mabrook el Soudani, an Arab laborer aged twenty-seven, was admitted to the Egyptian Government Hospital, Port Saïd, under the care of W. S. Robertson, M. B., C. M., at noon on June 25, 1885, suffering from "une affection extraordinaire de la bouche." The following history was in part obtained at the time, but the whole not until he was considerably better and able to articulate properly:

There was no traumatic history. His tongue had commenced to swell ten days previously. There was nothing in his family history to account for it, and he had enjoyed perfect health previously to the enlargement. He was sitting on the edge of the bed, with his head bent slightly over a basin, saliva running freely from the mouth. On raising his head his mouth was seen to be almost wide open. The tongue, protruding about one inch, was enlarged to at least three times its normal size: it was much coated, purplish in color, and hard to the touch, but he had little or no pain even on manipulation. The tongue was quite moist from the excessive salivation. There was no fluctuation. He could scarcely swallow, and his breathing was considerably impeded. The concavity under the chin was entirely gone; in fact, there was a slight convexity from the chin to the root of the neck from enlargement of the tonsils and surrounding parts. His temperature was 102° F., and his pulse 100. A diagnosis of acute glossitis was made, and, a cord having been passed through the tip of the tongue, so as to ensure a good hold of it, two long incisions were made, one on either side, on the under surface. A good deal of hemorrhage followed, and was encouraged by hot water.

On seeing him the following morning the sudden improvement that had taken place was striking. The tongue, although twice its usual size, was now withdrawn into the mouth and the salivation had greatly diminished. His temperature had fallen to 100° F., and his pulse to 90. He was ordered a smart purgative, with chlorate of potash (twenty grains to one ounce) for a wash and gargle. He was put on milk diet. From this time he continued to improve, and on the second morning he said he wanted to eat. For a day or two there was a slight hardness on the left side of the tongue in its middle third, which gradually disappeared. There was never at any time the slightest sign of bite or abrasion. He was discharged on July 10th, quite well.[3]

[1] *St. Louis Medical and Surgical Journal.* [2] *Amer. Cour. Obst.*
[3] *British Medical Journal.*

Elongation of the Uvula.

The uvula is subject to this form of disease. It may be acute or chronic. The mucous membrane covering the uvula is continuous with that of the mouth, and is liable to an extension of any inflammation that may occur in the mouth. The cellular tissue that comprises the stroma of the mucous membrane covering the uvula is especially obnoxious to infiltration of serum: this may assume an acute form, and the uvula increase very rapidly in size in the course of a few hours, becoming from five to eight lines in diameter, and extend so as to rest on the tongue, tip forward, or drop posteriorly and obstruct the larynx, giving rise to a feeling of suffocation or causing difficulty in swallowing.

In cases of this kind energetic treatment is indicated. Astringent gargles or puncturing the organ will usually afford temporary relief; but, as a rule, it is best to clip the most pendent portion. The chronic form is recognized—1st, by the history; and 2d, by the peculiar hacking cough and husky voice.

The constant irritation of the larynx and associate parts by the elongated uvula in some instances produces a chronic catarrh. The elongation may be congenital or the result of a polypoid growth. The polypus may extend to such a length as to at times drop into the orifice of the larynx and give rise to violent spasmodic coughing spells. The catarrh of the larynx may extend to the trachea and bronchi, and is said to have caused phthisis pulmonalis. Elongation of the uvula is very common, and, considering the simplicity of the treatment and the little danger attending operation, it is strange that patients will suffer from so annoying a disease without obtaining relief. Excision is the most efficacious form of treatment. The operation consists in first catching the most pendent portion with a pair of fixation-forceps, and then cutting off the lower third with long-handled curved scissors.

For the after-treatment[1] allow the patient to hold in the mouth small pieces of gum-acacia to relieve the sensibility and smarting. If the hypertrophy be due to cellular development, a more elaborate course of treatment will be necessary: sorbefacients must be administered; compression may be made directly to the parts by the use of collodion; the uvula must first be thoroughly dried and several coats of the collodion applied daily. The catarrh of the uvula may also be efficiently treated with astringent remedies—glycerite of tannin, etc. As a rule, little or no hemorrhage follows the operation of clipping. The tissues simply drain themselves of the infiltrated serum, and in a few days the uvula assumes its normal function.

The objection has been raised that the operation injures the voice. The writer had his uvula clipped by Prof. J. E. Garretson some five years since, and has never experienced any inconvenience therefrom, but, on the contrary, was decidedly relieved by the operation.

[1] Dr. Richard Neale, London, writes: I was much gratified to-day by the relief afforded to a sensitive girl by the use of cocaine to the painful stump after excision of the uvula. Two minutes after the use of a 2-per-cent. solution she exclaimed, "I feel not the slightest pain."—*British Medical Journal.*

Catarrhal Pharyngitis.

Catarrh of the pharynx may be either acute or chronic. It may affect all or part of the pharynx. The pathology is very similar to that of stomatitis; the uvula is generally involved, and the calibre of the pharynx is considerably lessened by the swollen and congested condition of the mucous membrane, the amount of swelling varying in different cases. In some instances the inflammation is confined to the soft palate and uvula; in others it may involve the posterior nares and soft and hard palate; then, again, it may be very circumscribed, attacking only the posterior portion of the soft palate or the posterior wall of the pharynx. The increase in the flow of mucus is generally marked. In chronic catarrhal pharyngitis the mucous membrane is thickened and congested, and is of a darker color than in the acute form; in other cases the induration occurs in irregular spots. The parts are covered with a viscid mucus that is more or less purulent. The lymphatic glands on the posterior wall are inflamed and swollen, and present a granular appearance. These glands become cystic, undergo cheesy degeneration, and ulcerate (follicular pharyngitis). This ulceration may extend and involve the nares and larynx.

Etiology.—Catarrhal pharyngitis is a progressive disease: the acute form occurs most generally in children and young people. Repeated attacks of the acute develop into the chronic form; one attack leads to another: some persons seem to have a predisposition to it; they are particularly susceptible to encroachment, especially in the fall of the year. It is essentially a fall and winter disease, it being very infrequent during summer: the chronic cases return every autumn.

The same causes that develop tonsillitis will bring on pharyngitis. Persons of a scrofulous diathesis are especially liable to it. Clergymen, from the ministerial tone of voice they adopt, are very apt to bring on chronic pharyngitis; public speaking and singing and the excessive use of tobacco or liquor are also predisposing causes.

Symptoms.—In the severer forms the first symptom noticed is a well-marked chill: this may be single or may be repeated in a few hours, and followed by a febrile movement with a temperature of 102° to 103° F. There is a general feeling of malaise: the patient complains of aching pains throughout the body and limbs. These constitutional symptoms are followed by local ones—swelling of the mucous membrane of the pharynx, which becomes congested; there is an increased flow of mucus and deglutition becomes painful. The elongated uvula may irritate the throat and cause a peculiar hacking cough. The constitutional symptoms may precede the local only a few hours; sometimes the local set in without the appearance of the constitutional symptoms. The patient in some cases simply complains of a sore throat, and upon examination an excessive quantity of mucus is observed—the parts look "juicy;" in other instances the exudation has formed a membrane covering the posterior wall of the pharynx and soft palate, very much resembling a diphtheritic membrane. In a few days, however, it begins to disappear in long shreds or strings: this latter form is met with most generally in children, and is very apt to be acute. In the severer forms the

inflammation may extend to the Eustachian tube, causing temporary deafness; the Schneiderian membrane may be involved; the tongue and mucous membrane of the mouth will present the same appearance as the pharynx. In the chronic form the voice becomes husky; the patient complains of a hacking cough which keeps him awake; he expectorates considerable tough yellow mucus, and is very apt to fear that he has consumption.

Prognosis.—Acute pharyngitis generally subsides in from four days to a week under judicious treatment. Chronic pharyngitis is not so amenable to medication, but constitutes one of the most perverse forms of catarrh. Astringents should not be used in the acute form until the inflammation has partially subsided: during this stage soothing remedies should be applied. Hydrochlorate of cocaine answers well in catarrhal inflammations. The bowels should be kept open with saline cathartics. Camphorated Dover's powder in seven- to ten-grain doses should be given to an adult. Sulphate of quinine in large doses will give good tonic results and check secretion of mucus. Hot vapor, medicated with some soothing remedy, may be used in the first stages. After the inflammation has somewhat subsided the acute form may be treated in the same manner as the chronic. The throat and mouth should be sprayed several times a day with astringent solutions of alum, borax, sulphate of zinc, or glycerite of tannin. Under this treatment the acute cases will generally make a recovery, while a certain number will have recurring attacks every fall, the disease thus becoming chronic. The chronic cases should be treated with spray two or three times daily, the same astringent drugs being used as in the later stages of the acute form. In some cases capsicum, in others dilute silver nitrate, iodine, or carbolic acid will be found beneficial.

The following are a few among the many methods of treatment which have been employed:

Acute Pharyngitis—Emollient Gargle.—M. Jasiewicz,[1] recommends the following in the acute stages of the different forms of pharyngitis:

℞. Cherry-laurel water, 60 parts;
Acetate of morphia, 1–20 " M.

A tablespoonful with two or three of warm water is used every quarter hour, being held in the mouth and allowed to trickle over the pharynx by holding the head far back. Two or three such baths render the pharynx much less painful.[2]

Gargle for Chronic Pharyngitis.—The *Union médicale* attributes the following formula to Bamberger:

℞. Chloride of ammonium, 75 grains;
Honey of roses, 750 "
Water, 12½ ounces. M.

To be used several times a day, together with mustard foot-baths, the use of tobacco being prohibited.[3]

Boroglyceride.—In cases of inflammation of the throat, as tonsillitis, pharyngitis, etc., a 50-per-cent. solution of boroglyceride, diluted about one-half with water, and carbolic acid added, used as a gargle, has rendered most satisfactory results. Tannic acid may be added with advantage; great relief

[1] *Union médicale de Paris.*
[2] *St. Louis M. and S. Journal.*
[3] *New York Medical Journal.*

is also afforded in cases of acute coryza by diluting a 50-per-cent. solution one-half, and drawing it through the nares by a forced inspiration.[1]

Pharyngitis.—Two grains of the chloride of ammonium, combined with ten or fifteen minims of the tincture of cubebs, given every half hour, oftentimes controls acute pharyngitis and superficial inflammations of the other tissues about the throat. For inflammation of the throat dependent upon a gouty diathesis add to this mixture ten minims of ammoniated tincture of guaiac, and administer every hour (Dr. A. A. Smith).[2]

Chronic Pharyngitis—Glycerinum Aluminis.—Robert William Parker, surgeon to the East London Children's Hospital, writes: I venture to suggest a new preparation of alum, which I can strongly recommend after a prolonged trial. It is made by dissolving one ounce of alum in five ounces of glycerin by means of a gentle heat. This is about four times as strong as a saturated watery solution. It is indicated in all cases where a powerful local astringent is required, and has the advantage over tannin of being far less disagreeable, equally astringent, and quite compatible with an administration of iron. In cases of chronic pharyngitis—so common in children—it is very efficacious; diluted with water, it forms a useful gargle, injection, or lotion.[3]

Granular Pharyngitis—Ignipuncture.—Dr. Balleygnier[4] recommends ignipuncture as the best manner of treating granular pharyngitis. He has tried all other known methods without obtaining a complete cure. The thermo-cautery is preferable to the galvano-cautery, which is not so easily manipulated, and should only be used when the granulations are small. A stem in the form of a large needle is adapted to the thermo-cautery. The patient should face the light and open the mouth wide. A spatula with a handle at right angles, and large enough to cover the entire surface of the tongue, is introduced into the mouth. The patient is told to take a deep breath in order that the pillars of the palate may be almost effaced. The thermo-cautery is gently applied to the granulations. A white eschar forms, which falls off between the fourth and eighth days. As a precautionary measure a string of asbestos may be wound round the metallic part of the instrument to within a centimeter of its extremity. A week ought to elapse between the cauterizations; eight or ten weeks generally produce a complete cure. Medical treatment should accompany cauterization.[5]

Tonsillitis.

Tonsillitis may be catarrhal, croupous, phlegmonous, or gangrenous.

Catarrhal tonsillitis, like other catarrhal inflammations, may be either acute or chronic, and involves the mucous membrane covering the gland and lining the crypts that dip into the stroma of the gland. The stroma, which constitutes the framework of the tonsil, is composed of fibrous connective tissue. In catarrhal tonsillitis this network is not involved. One or both tonsils may be affected at the same time. The mucous membrane becomes dryer and redder than normal: this is followed by an excessive flow of mucus, which sometimes collects in the crypts of the gland, showing as white spots on the tonsils. If detached and examined under the microscope, these will be found to consist of coagulated mucus, epithelial

1 *Philadelphia Medical News,* June 6.
2 *Medical Record.*
3 *British Medical Journal.*
4 *Thèse de Paris.*
5 *London Medical Record.*

cells, and in some instances bacteria. These patches increase in size and cover the tonsil with a membrane similar to that found in acute pharyngitis; sometimes by recurring attacks the acute form becomes chronic in a like manner to pharyngitis. Acute tonsillitis may arise from laceration of the mucous membrane of the mouth in extracting inferior wisdom teeth, the membrane having become adherent to the membrane of the neck of the tooth. As a rule, attacks of acute tonsillitis are due to climatic changes: the same causes that give rise to acute pharyngitis will develop acute tonsillitis. Tonsillitis is usually ushered in with fever and languor. Difficulty in swallowing is a characteristic symptom. The same treatment is required as for pharyngitis.

Professor DaCosta states that tonsillitis may often be aborted by an emetic if given early, when the pain and swelling are just beginning to appear. After the attack has been fully established the best treatment will be to keep the parts clean by the frequent use of mild boracic-acid or permanganate-of-potash gargles, and to prescribe small doses of pilocarpine or jaborandi sufficient to keep up slight salivation. If the swelling of the tonsils and difficulty of swallowing become very great, free scarification will generally give immediate relief.[1]

Croupous Tonsillitis.—Croupous tonsillitis is not a rare disease. The blood-vessels of the tonsil or tonsils are primarily affected. In acute tonsillitis there is an exudation of abnormal mucus. The thick mucus forms a false membrane. In croupous tonsillitis the membrane is composed of serum, white blood-cells, and desquamated epithelial cells. These become coagulated into a false membrane that covers the tonsils entirely or in part. The tonsils are more swollen than in simple acute tonsillitis.

Etiology.—There is little definitely known as regards the etiology of croupous tonsillitis: that it is a disease connected with the vessels that supply the glands there can be little doubt, for in all cases where we have a coagulation of fibrin there will be found a lowering of the vitality of the vessel-walls, which permits the escape of the white blood-corpuscles. It sometimes occurs as an epidemic: some claim that it is contagious. It sometimes follows as a sequela of the exanthemata, especially scarlet fever.

Symptoms.—Constitutional symptoms are always present and well marked. The rigors and fever may present themselves several days previous to the local expression in the tonsil. The glands of the neck are generally considerably swollen.

Prognosis.—Beyond the slight increase in size, as a rule, all evidence of the local lesion will have disappeared within one week. Not so the constitutional symptoms. The patient does not recover from the affection as he does from acute tonsillitis. He feels depressed for several weeks, and incapable of following his usual occupation.

Treatment.—The local treatment is similar to that employed in the other forms of tonsillitis: potassium iodide, iron, and quinine may be given to good advantage.

Phlegmonous Tonsillitis, or Quinsy.—Phlegmonous tonsillitis may be

[1] *Medical Bulletin.*

either acute, chronic, or gangrenous. It is a disease in which not only the mucous membrane, but the substance of the tonsil gland, is affected. The acute form of the disease may begin as an inflammation of the mucous membrane, and in a few days extend deeper and involve the substance of the gland. Then, again, the invasion of the disease presents first in the stroma or in one of the crypts of the gland. The tonsil and adjacent parts become very much swollen, and have a dark, angry, lobulated appearance. The intercellular tissue surrounding the crypts is swollen and presents as an angry ring surrounding the mouth of the crypt. There is a marked increase in the flow of mucus, and all that part of the mouth near the gland is covered with a thick yellow, viscid mucus secretion. In some instances the uvula and soft palate are involved and become congested and œdematous. The acute form, as a rule, ends in abscesses, which are oftentimes of considerable size and may involve the surrounding cellular tissue. The abscess generally points internally.

Etiology.—Quinsy is generally due to exposure to cold: it occurs in cold and temperate climates. It is sometimes hereditary. Persons who have suffered from one attack are liable to another, the recurrence in some cases being at stated periods, spring and fall. It is sometimes concurrent with the exanthemata, scarlet fever, measles, etc. Scorbutic or syphilitic persons are specially liable to quinsy sore throat.

Symptoms.—The local lesion is preceded by constitutional symptoms, rigors, and fever; the temperature in some cases rises to 103° or 105° F.; there is generally a feeling of malaise; the patient complains, yet does not go to bed. Anorexia, nausea, and vomiting indicate a disturbance of the stomach. These symptoms are followed in a few days by local pain and heat in one or both tonsils. This is succeeded by pain upon trying to swallow. The local pain increases; the tonsils become considerably swollen, frequently to the extent of almost completely closing the isthmus of the fauces. The mucous secretions are excessive, and the swelling may extend to the pharynx and mouth. The tonsils can be plainly felt through the external integuments. The patient suffers for a week or ten days, when the abscess points and breaks or is lanced. As a rule, the pointing is internal, but occasionally, though rarely, the abscess opens externally, as already been indicated.

Treatment.—In the treatment of this, as in other diseases where there is an excessive production of mucus, large doses of sulphate of quinine, given early in the attack, will sometimes abort it. One-drop doses of tincture of aconite, given every hour at the onset of the disease, are spoken very highly of. "Tincture of guaiac, in half-drachm doses every four hours, will abate the inflammation and cut short the disease in a remarkable manner" (Bartholow). The bowels should be kept open from the beginning, hot foot-baths are indicated, and astringent gargles of alum or borax should be used to clear the mouth of mucus. If the patient is suffering so as to be unable to sleep, hypodermic injections of morphia may be necessary. Poultices should not be applied. If the pain is not too great, the abscess should not be lanced, but if there is any indication of pointing, it may be lanced on the fifth day. Lancing previous to this will generally aggravate rather than allay the

pain. Excision should not be made except as a *dernier ressort.* If the uvula becomes very much swollen and the symptoms are grave, complete excision of that organ may be made with beneficial results: convalescence is rapid.

Chronic Phlegmonous Tonsillitis, or Hypertrophy.—Hypertrophy of the tonsil gland may follow an acute attack, but generally comes on gradually. It is most often met with in young children, while the acute form is rare in persons under twelve years of age. The glands may increase in size, so as nearly to occlude the oropharyngeal space. Chronic phlegmonous tonsillitis causes a permanent change in the voice, giving it a peculiar nasal twang. Full respiration is also interfered with. The disease occurs in weakly, scrofulous children. Bryant in his *Surgery* cites two cases where, on removing the glands, he turned out from the gland distinct tumors "about the size of nuts," which under the microscope could be distinguished from the tonsil.

The local lesion is the expression of constitutional debility, and the treatment should be directed toward the building up of the child—lactophosphate of lime, cod-liver oil, quinine, iron, and iodide of potassium. If possible, send the patient to the seashore for the summer; if not, order salt baths and plenty of out-door exercise. When the enlargement has lasted for some time and the gland presents a lighter color than normal, excision must be resorted to. Experience teaches that the latter is about the only thing that promises permanent relief. In the hands of those who are not skilled in the use of the knife, and especially where the operation is to be performed on children who are not old enough to be reasoned with, the use of London paste will be found an excellent means of removing hypertrophied tonsils. "The following are the directions given for the preparation and the use of the paste:[1] A quantity of equal parts of finely-pulverized and well-mixed caustic soda and unslaked lime is kept on hand. When an application is to be made to the tonsils a little of the powder is put into a small porcelain cup; a few drops of absolute alcohol, which is kept near at hand, are added; the two are carefully mixed with a glass rod, when the paste is ready for use. Care must be taken, however, that it be of the proper consistency. If too thin, it is apt to find its way to parts that ought not to be touched; if too thick or lumpy, the paste will not readily stick and little pieces might be swallowed. To apply the paste a glass rod of sufficient length may be used: one end of it, which must be smooth and slightly funnel-shaped, is dipped into the paste, and a greater or less portion of the surface touched as occasion may require. A grooved director is also recommended as a suitable instrument for applying the paste. To apply the paste the patient is to be placed in a position for laryngoscopy. The tongue is then to be depressed with a spatula, and the paste applied to the enlarged surface for two or three seconds. The action of the escharotic upon the tonsil is rapid. The mucous membrane almost instantly assumes a deep flesh color, and presently a dark, blackish spot is seen streaked with blood. The following day the tonsil is covered with a whitish-yellow eschar. The inconsiderable amount of suffering produced by this cauterant is noticeable. Children pay

[1] Garretson's *Oral Surgery.*

scarcely any attention to the pain or make light of it. At longest, the discomfort lasts only two or three minutes. Subsequent applications are accompanied with less discomfort, if with any at all. The operation is to be repeated each sixth day. The number of touchings required will depend upon the nature of the case. The good results obtained from the use of this paste are not exaggerated by Dr. Ruppanea (who may be said to have first made its use practical). Still, the experience of the author makes him unwilling to agree that such a mode of cure will displace entirely the use of the knife. Over-commendation, however, is not to be given the process: it is above praise. The practitioner, experienced or inexperienced in the use of the knife, may put full confidence in the London paste."

Where it is not possible to see the patient so often, or where the operation is to be performed on a young child, or if the operation becomes necessary to relieve grave symptoms of suffocation, the guillotine may be used, to which preference is always to be given over the knife. Abroad the galvano-cautery is very much resorted to.

Gangrenous Tonsillitis.—Gangrenous tonsillitis seldom occurs as a primary lesion, but is found as the sequela or complication of the exanthematous fevers, scarlet and typhoid; less frequently it accompanies measles. It occurs in the latter stages of these diseases or follows during convalescence. The case may appear to be progressing favorably when a sudden rise in temperature will be observed, this being followed by extreme prostration. The patient will complain of a soreness of the muscles of the throat and difficulty in swallowing. If an examination of the throat be made, it will be seen that the swelling involves one or both tonsils and the pharynx; later, black patches make their appearance on the tonsils. The patient grows rapidly worse. The pulse becomes rapid and feeble, and delirium sets in. The temperature falls below normal, and death follows, as a rule, in a few days. The disease is almost necessarily fatal. Treatment is of little avail.

Calculus Removed from a Tonsil.—Mr. F. A. Nixon exhibited at the Academy of Medicine of Ireland a hard calculus removed from one of the tonsils of a gentleman who complained of a slight obstruction of his throat. Being in the habit of singing, he complained of the obstruction. Both tonsils were considerably enlarged. A small white speck being detected, the probe elicited a metallic ring. Having failed to grasp the mass with instruments, he enucleated it with his finger. The greater portion was behind the soft palate. There was considerable hemorrhage. Dr. E. H. Bennett said the specimen was of great rarity, and moved that it be submitted to the committee on reference. It indicated articulation either with another calculus or an adjoining bone. Mr. Corbett thought the formation was identical with the tartar that often formed about neglected teeth. He had seen several teeth blocked together by it even in young mouths. Mr. Nixon said the gentleman's tonsils were very large and were not atrophied. The calculus was similar to the tartar formation on teeth. The teeth were black and had a good deal of tartar. The gentleman was a great smoker.[1]

[1] *British Medical Journal.*

Nasal Catarrh.

Catarrh of the nasal passages may be acute, chronic, or purulent. Acute nasal catarrh is similar to catarrhal inflammations of other mucous membranes. There is first a sense of increased heat and dryness: this is quickly followed by an increased flow of mucus. There is a pricking sensation in the nasal cavity, often accompanied by sneezing. At the commencement of the attack, upon inspection, it will be seen that the mucous membrane is of a very red color; this soon gives place to a darker red, indicating that extensive congestion has occurred. We

Fig. 145.

Mucous Transformation of Cells from Catarrhal Inflammation of Air-passages: *a*, degenerated cylindrical cells; *b*, pus-corpuscle; *c*, same acted upon by acetic acid; *e*, *d*, *f*, cells coming from division of a cylindrical cell, showing cilia; *g*, *h*, mucous degenerated cells from the nasal fossa in coryza; *j*, cylindrical cells, showing endogenous cells (× 450).

now find mixed with the mucus white blood-cells, but as the disease progresses the discharge becomes of a more serous character, the mucus giving place to serum. The proportion of white blood-corpuscles increases and the discharge becomes thicker. It may assume a greenish tint, which indicates that the inflammation has reached a stage when the walls of the vessels are seriously damaged, and that the red blood-cells are migrating: when such is the case the disease is very apt to become chronic.

Symptoms.—The patient complains of a sense of fulness and distress in the nasal cavity and the frontal sinus, and in the Eustachian tube, lachrymal apparatus, and antrum of Highmore. These symptoms are often accompanied by a dull headache, which is relieved by the free flow of mucus that succeeds.

Etiology.—Acute catarrh may be caused by exposure to a draught, with consequent chilling of the surface of the body. The nasal passages, being the first to come in contact with the air, are most liable to be affected. The direct action of irritating chemicals, dust, and other particles floating in the air, the inhalation of tobacco-smoke, especially

cigarette-smoke, and many other causes of like nature, may provoke catarrhal attacks. These alone, however, are, as a rule, not sufficient in themselves to produce the disease. The fact that we are susceptible to the draught or local irritant presupposes a previous depressing influence. This predisposing cause may be a too warm room, a too hot bath, too vigorous exercise, or any agent or surrounding that will lower the *vis vitæ* of a part, or destroy or relax the tonicity of capillary vessels. Acute catarrh may also arise from acrid mucous secretions due to constitutional derangement.

Treatment.—Treatment consists in allaying the congestion. Hydrochlorate of cocaine is very highly spoken of, a 4-per-cent. solution to be applied locally; also upon retiring a hot foot-bath and a seven-grain camphorated Dover's powder. Many other remedies may be used —a saline cathartic and the inhalation of ammonia salts, etc.; in fact, any remedy that will restore the equilibrium of the circulation, which has been temporarily disturbed, will be found efficacious. The following methods are highly recommended:

The Neurotic Treatment of Coryza.—Dr. Lees recently read a valuable paper before the Medical Society of London upon the nature and treatment of coryza, in which he called attention to the troublesome consequences that frequently follow a neglected cold, and to the unsatisfactory results that are sometimes obtained from the usual treatment by laxatives or diaphoretics. Dr. Lees defined coryza to be a neurosis of the vaso-motor nerves of the nasal and contiguous mucous membranes, excited directly or in a reflex manner by impressions of cold on the cutaneous nerves. He pointed out that congestion of the nasal mucous membrane was the result of this vaso-motor disturbance. The question of the parasitic origin of coryza was considered, and the arguments in its favor stated, including the contagious character of some colds and their analogy to whooping cough, measles, and influenza. The mass of evidence, however, is not in favor of the germ theory of the origin of the disease.

In reference to treatment Dr. Lees maintains that, as coryza is a neurosis, relief must be sought for in neurotic remedies. The therapeutic indications are three: to allay the excitability of the central nervous system, to lessen the congestion and hyperæsthesia of the nasal mucous membrane, and to arrest the discharge if it has commenced. Opium may be given to meet the first indication, but bromide of potassium is more efficient and entirely safe. The second indication can be fulfilled by painting the interior of the nasal tract with a solution of cocaine. The discharge can be promptly arrested by the administration of belladonna. In practice Dr. Lees has found the following method to be admirably successful in cutting short a cold: To an adult patient he usually gives from forty to sixty grains of bromide of potassium, to be taken at once, a similar dose to be taken six hours later, and another dose, if necessary, at the expiration of the second six hours. He also directs the patient to take from five to seven minims of the tincture of belladonna every hour or two until the throat feels dry. Locally, he directs the nasal mucous membrane to be painted with a 4-per-cent. solution of cocaine. This invariably gives great relief, and in some cases is sufficient to effect a cure without any other medication. In conclusion, Dr. Lees related a case in which the administration in divided doses of ten grains of bromide of potassium and five minims of tincture of belladonna had cured in less than forty-eight hours a marked attack of coryza

and bronchial catarrh in a weak, rickety child aged four years. In view of the alarming condition of the child before treatment was instituted Dr. Lees considered it probable that a fatal result was averted by the employment of the neurotic treatment of coryza, instead of the usual depressing diaphoretic or laxative plan.[1]

Catarrh of Nasal Canal caused by Maggots.—Dr. Fred. Humbert reports cases in which the fly deposited eggs in the nostrils, and they there developed. The skin of the maggot is horny, hence remedies will not readily act upon it. He recommends carbolic-acid injections and hypnotics. When the maggots are mature they drop out of their own accord, and, since they have no reproductive power, there is a natural limit to the disease if we can support the patient's strength. Some cases have terminated fatally.[2]

Coryza.—Surgeon-major G. E. Dobson writes in *The Lancet*, describing a plan of treatment for coryza which is certainly simple enough, and which he claims is very effective. About a drachm of camphor, coarsely powdered or shredded with a knife, is placed in a small pitcher, which is then half filled with boiling water. The patient, having made a paper cone large enough to surround his face by its wide extremity and the mouth of the jug by its narrow end, proceeds to respire freely, at each inhalation drawing the steam into his nostrils, and at each inhalation forcing it up against the outer surfaces of his nose and adjoining parts of the face. A twofold action is produced: the camphorated steam acts internally in a specific manner upon the whole extent of the mucous surfaces, and externally produces profuse diaphoresis of the skin covering the nose and face, there acting as a derivative from the inflamed Schneiderian membrane. The pitcher should be wrapped in a woollen cloth to retain the heat in the water, or, better still, a tin vessel under which a spirit-lamp is burning may be used.

Acute Coryza.—Dr. S. S. Cohen recommends, as a specific against acute coryza, the $\frac{1}{120}$th of a grain of atropia, to be repeated every four hours until there is dryness of the throat. He says that this remedy will cure nine out of ten cases of coryza if taken at the incipiency of the disease. Afterward, to relieve the unpleasant symptoms of dryness, he has given $\frac{1}{16}$th of a grain of pilocarpine with good results. When cases are seen too late to use atropine with advantage, he has obtained good results from ammonium salicylate in doses of ten to fifteen grains repeated every two hours until tinnitus aurium is produced. If the patient does not object to the expense, cocaine can be used to allay the local symptoms until the medicine has had time to act.[3]

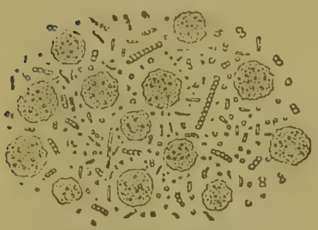
Nasal Catarrh.—Cubeb is the remedy most relied on in the throat-room for constitutional impression in the ordinary form of the complaint. Fifteen or more drops of the oleo-resin, on sugar, after meals, or a few grains of the recently-prepared powder, with two or three grains of salicylate of cinchonidia, in pill or capsule, is the form in which it is usually prescribed. Cleanliness by douche or spray is essential in giving the parts a chance to get well, which they often will do by cleanliness alone, without any topical medication.[4]

Chronic Nasal Catarrh.—Chronic catarrh is the result of oft-repeated acute attacks, giving rise to a loss of tonicity in the walls of the vessels, with chronic congestion of the corium. There is a constant hyperæsthesia of the mucous membrane and a persistent discharge of a muco-puru-

[1] *Medical Bulletin.*
[2] *Journal American Medical Association.*
[3] *Philadelphia Medical Times.*
[4] *Polyclinic.*

lent fluid. This forms a permanent source of irritation. Very often the local catarrh is caused by these acrid secretions, which are the local manifestations of some constitutional disease. Permanent thickening of the mucous membrane of the nose may arise from these chronic conditions. Sometimes the discharges in chronic catarrh adhere to the mucous membrane of the posterior nares and pharynx in the form of dry greenish or brown crusts. The retained exudations putrefy and give rise to a fetid condition known as *ozæna.*

FIG. 146.



Fetid Pus, showing common active bacteria amongst the pus-corpuscles (× 600).

Treatment.—The treatment of nasal catarrh should be directed to the general system as the surest means of curing the disease. The patient should be put upon tonics: cold salt baths, begun in the middle of the summer and continued on through the winter, are highly recommended. Plenty of out-door exercise and a good nutritious diet are to be advised. The local treatment should consist in spraying the mucous membrane with warm alkaline solutions and mild astringents. Iodoform is very highly recommended to dust over the denuded surfaces.

Ozæna.—Ozæna, according to the definition of Roth,[1] consists of a chronic inflammatory process of the nasal mucous membrane, with a tendency to atrophy; the secretion from the glands becomes altered, forming a membrane containing organisms which decompose and cause the intolerable odor. The following points are demanded of therapeutics: 1, to soften the dried secretions, remove them, and prevent their formation; 2, to restore diseased mucous membrane to a normal condition; 3, to removing the odor. Roth makes an effort to accomplish this by the dry tamponnade of Göttstein. In the morning he employs a mixture consisting of the following ingredients: Thymol $\frac{1}{10}$th per cent., carbolic acid $\frac{1}{2}$ per cent., with a 1 to 2 per cent. solution of tannin of alum, by means of a spray. He claims that by this process even the remotest portion of the nasal mucous membrane is reached.[2]

Opinions differ and many theories have been advanced concerning the cause of the odor of ozæna, and Dr. McBride after briefly reviewing these theories gives his preference to that of Frankel of Berlin, who maintains that it is necessary to assume the presence of a specific ferment in cases of ozæna to meet the fact that atrophic catarrh sometimes, though rarely, exists without odor. Ozæna may be said to be always associated with atrophy of the nasal mucous membrane. If the secretion be examined in its fluid state, it is found to consist of pus-cells and enormous quantities of bacteria. By way of treatment, while douching and syringing are doubtless beneficial, they are not to be compared in efficacy or safety with the anterior nasal spray. According to Dr. McBride's own experience, the most satisfactory results are obtainable from an alkaline and antiseptic spray, immediately followed by one containing as much tincture of iodine as the patient can bear, which usually does not exceed five minims to the ounce.

Any simple treatment which is efficacious in so troublesome a complaint as ozæna is a desideratum. Dr. Göttstein (*Berlin Klin.*) believes that ozæna is due not to a congenital narrowing of the nasal fossæ, but to their being too wide. The current of expired air loses its force and becomes

[1] *Deutsche Medizinal Zeitung.* [2] *Thérap. Gaz.*

powerless to remove the products of secretion, which, being retained, become fetid. The author has always found a condition of atrophy and anæmia of the mucous membrane of the turbinated bones in ozæna. He has always found advantage in plugging the nostrils with cotton-wool, so as to slow the passage of air. Under the influence of this plugging the mucous membrane resumes its vitality, and the secretions become normal again and the ozæna is cured.[1]

Diphtheria.

Diphtheria is a specific infectious disease. It is a process of coagulative necrosis. The lesion primarily consists in a croupous inflammation, which is not, however, necessarily caused by the poison of diphtheria. Croupous inflammations of mucous membranes, as we have seen, consist of a local lesion in which there is formed a false membrane located on the surface of the mucous membrane. This false membrane is made up of pus and epithelial cells held in a mesh of coagulated fibrin, and is easily detached, but is quickly replaced by a further exudation from the capillary vessels, which is again coagulated on the surface. Such is the pathology of a true croupous inflammation (membranous croup).

In diphtheria the process of infiltration and coagulation is deeper seated: not only is a false membrane formed on the surface, but the substance of the stroma is invaded. Superficially, the membrane resembles the croupous membrane, but if we try to detach it we will find it firmly adherent. If it is forcibly removed it leaves a raw, bleeding surface. There is no clear line separating the false from the true mucous membrane. The epithelium is completely destroyed, as is also the superficial layer of the corium. For the microscopical appearance of the diseased tissues in diphtheria I cannot do better than quote from G. Sims Woodhead's *Practical Pathology*, p. 327. He says:

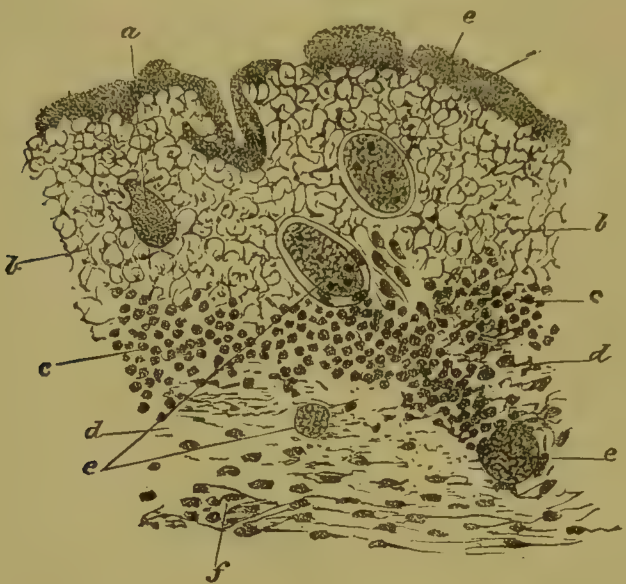
"In the earlier stages there is found in the affected area the following appearances, which may be noted under a high power (× 300): Usually on the surface, and extending for some distance into the tissues, are masses of micrococci, which take on the methyl-aniline staining very deeply. The epithelium forms merely a heavy network, of which the margins of the cells apparently form the meshes. Beneath this altered epithelial layer the connective tissue is infiltrated with fibrin and leucocytes, most of which are accumulated around the distended blood-vessels. Around these distended vessels, too, hemorrhages are frequently seen, but there are as yet few masses of micrococci in the lymphatics and in the deeper tissues generally, and the cell-infiltration is confined to the tissues immediately beneath the epithelium of the point of infection. At a later stage, when the false membrane has formed, and has perhaps sloughed, leaving a gray, sodden, sloughy, and infiltrated-looking surface, a piece of the tissue must be treated with alcohol and methyl-aniline violet and examined microscopically. The following appearances may be distinguished: The gray, sloughy part is usually teeming with masses of deeply-stained micrococci, but there is now no trace of epithelial structure left. The connective tissue is transformed into a mass of fattily degenerated or homogeneous material, which is very characteristic of the diphtheritic condition, infiltrating the connective tissue. A fibrinous

[1] *Cincinnati Lancet and Clinic.*

exudation, in which the masses of micrococci are situated, often forms a false membrane on the surface.

"The blood-vessels are distended, and are surrounded by a large number of round cells or leucocytes. This accumulation of cells takes place espe-

FIG. 147.



Section of Uvula, from which the Epithelium has been Detached, from a Case of Diphtheria, stained with Methyl-aniline Violet (× 100): *a*, micrococci; *b*, amorphous submucous tissue; *c*, leucocytes infiltrating tissue; *d*, fibrinous exudation; *e*, blood-vessels; *f*, lymphatic vessel, in which are accumulated small round cells and fibrin.

cially at the point of junction between the submucous and the deeper tissues. There is a further quantity of fibrinous lymph, in which there are a few leucocytes. The lymphatics for some distance around are choked with lymph, or more frequently with masses of micrococci.

"Micrococci may be found in any part of the slough. The distinctive characteristics between this condition and the so-called croup are, that in diphtheria the micrococci and the slough are always present, but in the fibrinous exudation, though usually present, is not essential, whilst in croup the exudation is; and the micrococci, if present, are found only on the surface, do not invade the mucous membrane or the surrounding lymphatics, and so do not get into the system to give rise to constitutional symptoms."

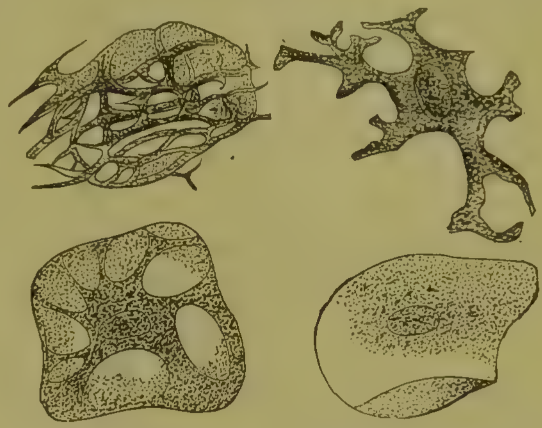
This accords with observations made by other pathologists, and seems to be borne out by clinical experience.

The diphtheritic membrane is generally confined to mucous membranes, but where the skin is abraded it may, and sometimes does, appear. It also may affect wounds. Its most common seat is the pharynx, tonsils, soft palate, uvula, and nasal passages; less frequently it is found in the œsophagus, stomach, and vagina.

Upon an examination of the throat with a mouth-mirror or laryngoscope the mucous membrane, if it is in the first stage of the disease, will present a dark, turgid appearance: this may be only in spots on one of the tonsils or uvula, in the centre of which will be seen a small white patch or false membrane. The patient complains of difficulty in swallowing and soreness of the throat, or does not complain at all.

A general feeling of malaise is apt to accompany the onset of the disease: the small white patch of to-day, however, may be a confluent membrane to-morrow. In the most simple form of the disease the epithelium may desquamate and the infiltration in the corium be absorbed, but in the majority of cases the infiltrated tissue sloughs, and in the more malignant forms gangrene of the deeper tissues may ensue. The death of the part may result from the plugging of the arteries by swarms of micrococci. They are found in the tissues and lymphatics in vast numbers. The lymphatic and salivary glands may become swollen, suppurate, and pus be discharged through the external integument.

Fig. 148.



Fibrinous Degeneration of Pavement Epithelial Cells in Diphtheritic Membranes (high power).

Etiology.—That the disease is contagious, and can be, and is, transmitted directly from one person to another, there can be no doubt; but as to whether it is first a local and afterward a general disease, or *vice versâ*, there is considerable difference of opinion. Some claim that the system becomes gradually poisoned from the local infection; others hold that it belongs to the same class of infectious diseases as typhus and typhoid fever. On its specific nature and contagiousness all are agreed.

"From a clinical standpoint," says Loomis, "it seems that the disease starts locally—that some particle, for instance, of the exudation, too small to be detected by the unaided eye, is received on the mucous membrane of the pharynx, nose, mouth, larynx, trachea, vagina, or upon a cut or abraded surface, and thence contaminates the whole system. The point of infection cannot be determined until after constitutional infection has taken place.

"It seems to be well established that when the local signs of diphtheria are present there is already a constitutional infection. The experiments of Oertel and others show that the point of inoculation is the point from whence radiates the disease. Experiments are now being made which tend to show that in virulent fluids it is not the bacteria but the chemical element that is capable of inducing the grave symptoms which sometimes follow inoculation. The stage of incubation usually varies from one to eight days; it may last one month: when the disease is directly communicated, as in some recorded instances where a piece of diphtheritic membrane is dislodged and coughed into the mouth, nose, or eye of the physician or attendant, the disease has developed in twenty-four hours. But the question arises: May not the one thus attacked have been under the influence of the diphtheritic poison for some time, and thus be prepared for the rapid reception of the local poison? During epidemics the period of incubation is shorter, and there is reason to believe that the more virulent the poison the less time elapses between exposure and the initial symptom.

"As a rule, the latent period in diphtheria rarely exceeds five days."

The opinion of most of the leading physicians of the present day favors the theory of infection by direct contact or transmission. The

belief of its spontaneous origin is rapidly losing ground as our knowledge of infectious diseases advances. Diphtheria is no respecter of age, sex, or condition in life. Its ravages are as unrelenting among the rich as the poor. A previous attack does not preclude a subsequent one. It is most common, in its malignant form, between the ages of two and five years; bad hygienic surroundings aggravate its malignancy by depressing the *vis vitæ.*

Diphtheria is generally of a mild form in adults, from the fact that the patches are mostly situated on the tonsils or in the nares, whose surfaces are less closely related with the general lymphatic system than is the mucous membrane of the pharynx and mouth. As long as any vestige of the membrane lasts it is contagious. Prof. Jacobi of New York, who has had as large an experience, probably, as any other practitioner in this country, claims that the disease is spread by adults, and cites several cases. He says the danger arising from the contagion spread by adults affected by mild forms of diphtheria is increased by the fact that in them diphtheria is apt to assume a chronic character without losing its contagious nature, in proof which he cites the following cases:

"An unmarried shopkeeper called on me several times in the course of a few weeks for a trifling complaint. Of his throat he did not speak at all, but I discovered a few patches, first on the left, afterward on the right, tonsil. My warning not to go to his store, lest he might get seriously ill or infect others, was not heeded. He attended to his business, coming in contact with a hundred women and children daily for weeks, until he was laid up for a week, to return to his dangerous and nefarious occupation as soon as he felt a little better. A schoolmistress I have known to teach all day for ten days with diphtheritic patches in her throat. I could prevail upon her to retire a week from work only by threatening that I would communicate with the parents of some of her pupils about the danger the children were running. Two families of my acquaintance had the same experience with their large houses full of children. They had never had diphtheria until they employed a seamstress who came daily from her residence in another part of the city. Attacks of diphtheria followed each other in quick succession. The houses were examined from attic to cellar, the sewer was disturbed, the traps were changed. The health of the people did not change with the plumbing. At last the suspicion of contagion was roused. The seamstress came from a neighborhood and a family where diphtheria was endemic. From that time the woman was dispensed with, and no diphtheria has made its appearance in those families these six and three years. In the family of a physician there were two children—a boy, in good health otherwise; a girl, robust and vigorous. Both suffered from diphtheria repeatedly for many years, until the girl came near dying and the boy died. What was the cause of the constant attacks dragging over years? The fact had been overlooked that it so happened that almost every time when the children were sick the old, trusted, and trustworthy nurse was also affected with diphtheria, sometimes seriously. What, however, was not known at that time, and was discovered later—indeed, too late—was that the woman had concealed many an attack of throat disease, fever, difficult deglutition, out of a sense of duty—that she had often repeated those medicines which she had been supplied with before. In the early part of the summer of 1883 the boy died; the surviving girl was

sent to the country; also the nurse, who had been sick with diphtheria for weeks. While in the country the child was not in so close and intimate company with her nurse as in the city and in winter. They returned to the city in September. In October the child was taken sick with diphtheria, the nurse having taken 'throat medicine,' unknown to anybody, for some time. Then the nurse was discharged; that was the end of diphtheria in that family.

"If I add that in several families diphtheria broke out among the children after new servants had been engaged, and that these servants were found affected with throat disease, I think I only state the experience of many other practitioners.

"Isambert has the case of a medical assistant who for fully nine months (both in Paris and abroad), and even after his general health had been considerably improved, expelled membranes daily from his nasal cavities. Cadet de Gassicourt publishes cases of pharyngeal and nasal diphtheria of forty-five and one hundred and fifty-one days', and one of laryngeal diphtheria of sixty-five days', duration. Most of the cases recorded ended in recovery. While the disease lasted it was a source of danger to the person affected. This, however, is *not the greatest danger*: the contagion spreading from them is of greater importance than the risk run by the individual. Nor is the severity of such a case the most formidable danger. For a person dangerously ill is in bed and a source of evil to those only immediately around him. Those, however, who feel well or well enough to be about are the scourge of the community at large, particularly as mild cases, being neglected, have a tendency to last long.

"Isambert's assistant was travelling half a year to get rid of his nasal diphtheria. He recovered, but how many deaths did he spread from railroad-car to railroad-car, from stage-coach to stage-coach, from hotel to hotel? To all these curses strewn out by the luckless wanderer after his own health, how many physicians have looked, in the sporadic cases occurring here and there and in the endemics or epidemics generated by them, for the local cause of the supposed primary indigenous origin? Nobody suspected the traveller, who probably left days before, as nobody traces every outbreak of cholera to the unknown person who carried it upon his person or in his bowels."

Owing to the alarming prevalence of the disease in adults, dental practitioners should become fully acquainted with the appearance of the disease in its local manifestation, in order that both themselves and patients may be protected from infection.

Symptoms.—In diphtheria, as in some of the diseases which we have considered, there are local as well as constitutional symptoms, but they are not the same for all cases; and in this diphtheria differs from other infectious diseases. The patient complains of a sore throat, difficulty in deglutition, and a general feeling of weariness; will fail to keep his appointment, or doing so will remark, "I felt so weak I did not think I could come to-day," or some such expression. The onset may or may not be accompanied by fever. If you examine the patient's throat, you will probably find one or more small patches of false membrane situated upon the uvula or tonsils. This false membrane gradually extends over the mouth and pharynx, and sometimes involves the nasal passages. The disease may run a very mild course, and the patient, although feeling sick, will not go to bed, but will remain up and per-

haps attend to business. The membrane may not extend, but remain as small patches on some part of the pharynx, mouth, or nares. Not unfrequently those cases that begin in such a mild manner suddenly grow worse, and the patient dies unexpectedly. In other cases the membrane, after six or seven days, loosens and is coughed up: then, again, it may assume a chronic form and last for a longer or shorter time. In the most malignant cases the patients are taken with a high fever and convulsions; the cerebral symptoms grow rapidly worse, and the patient dies in three or four days.

In thus treating of diphtheria it has been my object to give its pathology and symptomatology, so that we may be able to recognize the disease when we see it, and thus be able to point it out to patients and advise accordingly. The patient should be informed of the gravity of the lesion, and the danger, not to himself only, but to others; he should be isolated from the rest of the family, and the family physician notified at once. By our knowledge and timely action we may prevent the spread of the disease.

Treatment.—As the treatment of this disease does not pertain to the practice of the dental specialist, its full consideration here has not been deemed necessary. The general features of treatment are indicated in the following extracts from the admirable treatise of Dr. A. Jacobi:[1]

"Every case should be treated on general principles; thus, it is not possible to lay down a routine treatment for every individual case. High fever should be reduced by sponging and bathing, quinia, and sodium salicylate; collapse speedily treated, and severe reflex symptoms, as vomiting, etc., checked at once. Whether to employ for this purpose ether, wine, cognac, champagne, or coffee must be decided by the physician in individual cases. The administration of the remedy, whether by mouth, by injection into the bowels, or subcutaneously, as I have employed cognac, ether, alcohol, and camphor dissolved in ether or alcohol, in some cases with decided and rapid success, must depend on the condition of the organs and on the urgency of the case. However, all the above remedies are frequently of no service, because administered too late and in too small doses, If I have ever had cause to feel contented with the results of treatment in diphtheria, it is owing to the fact that I lost no time. No medicines, however, must be resorted to which are apt to derange the digestion of the patient; alcoholic stimulants must be given in fair dilution only, for that reason. The nourishment of the patient is a matter of very great importance. On general principles it is true that care must be taken in regard to food administered to febrile patients, but we must bear in mind that, when the lymphatic vessels are kept empty and no new and proper material is introduced into them, the absorption of locally-existing poisonous substances is proportionately increased. Hungry lymph-vessels are the organism's fiercest enemies."

"In regard to the dose of stimulants, it is a fact that there is more danger in diphtheria from giving too little than too much. When the pulse barely begins to be small and frequent they must be administered at once. A three-year-old child can comfortably take thirty to one hundred and fifty grammes (f ℥j–v) of cognac, or one to five grammes of carbonate of ammonium, or a gramme of musk or camphor (gr. xv) and more, in twenty-four hours. In the septic form especially the intoxicating action of alcohol is

[1] "Diphtheria," *System of Medicine*, Lea Brothers & Co., Vol. I. p. 656 *et seq.*

out of the question; the pulse becomes stronger and slower, and the patient enjoys rest. In those cases in which the pulse is slow, together with a weak heart's action, the dose can hardly be too large. The fear of a bold administration of stimulants will vanish, as does that of the use of large doses of opium in peritonitis, of quinia in pneumonia, or of iodide of potassium in meningitis or syphilis. I know that cases of young children with general sepsis commenced immediately to improve when their one hundred grammes (f℥iij) of brandy were increased to four times that amount in a day."

"*Special Treatment.*—The first axiom in the treatment of diphtheria is that there is no specific; the second, that in no other disease the individualizing powers of the physician are tested more severely.

"The treatment is both internal and external. The local remedies are either such as dissolve the mucous membrane, or such as thoroughly modify the mucous membrane from which the pseudo-membrane has been removed, or real antiseptics, with the power of destroying either chemical or parasitic poisons.

"The number of remedies recommended in diphtheria is immense. No other proof of its dangerous nature is needed. In the following I shall review those which I consider it worth while either to reject or to recommend.

"Steam is used partly to soften the membranes, but principally to increase the secretion from the mucous membrane, and thereby throw off the superjacent membrane. This can be done to advantage only where there is a natural tendency to it; that is, where there are a great many muciparous follicles under a cylindrical or fimbriated epithelium. This is the condition on part of the pharynx, but not on the tonsils; and in a small portion of the larynx, in the trachea and bronchi, but not on the vocal cords. Wherever there is pavement epithelium on the normal surface, and where the membrane is imbedded into the tissue, steam can hardly be expected to do good. In the other cases it will. Thus, the locality of the diphtheritic process determines to a great extent whether steam is indicated or not. If it be used, the necessity of a full supply of atmospheric air must not be disregarded. Steam, with an overheated room and without pure air, is liable to be as injurious as steam in pure air is beneficial in a number of cases.

"There can be no better proof for the necessity of individualizing, and the impossibility of treating all cases alike, than the fact that many will do well under steam treatment, and others are certainly injured by it. I have repeatedly had the joy of seeing children with croup become less cyanotic after their removal from an atmosphere of vapor, and I can readily see that pure atmospheric air would be more agreeable and wholesome to a child with stenosis of the larynx than an atmosphere laden with steam. Of course this remark does not apply to cases of pseudo-croup and bronchitis, which are generally benefited by a warm, moist atmosphere. Those, however, who deem it judicious to employ steam as a vehicle for carbolic acid, salicylic acid, chloride of sodium, chlorate of potassium, or lime, had best resort to the atomizer for applying these remedies. It can be used without trouble; most children are sufficiently intelligent to allow the spray to be directed upon the fauces and larynx every ten or fifteen minutes in case of necessity. When it is deemed advisable to administer steam, I warn against the use of gas stoves. They require a great deal more oxygen than an alcohol lamp, which ought to be preferred when a stove or slaking lime or hot iron or bricks immersed in water are not available.

"Water may be made serviceable in different ways. Its effect on the skin, when taken in large quantities under normal or abnormal circumstances, is a matter of daily experience. Copious perspiration is its imme-

diate result. The very same effect is produced on the mucous membranes. In diphtheria, besides professional hydropathists, I know of but one[1] who favors the plentiful use of water, 100–200 grammes (3–6 ounces) every hour or oftener, either by itself or mixed with an alcoholic beverage.

"Severe inflammatory symptoms, such as redness of the throat, great pain, swelling of the glands, require cold applications, either an ice-bag or ice-cold cloths well pressed out and frequently changed. They must, however, be placed where they can do most good—in laryngeal diphtheria around the neck, in pharyngeal diphtheria with glandular swelling over the affected part. In the latter, therefore, the flannel cloth which covers the whole of the application must be tied over the head, and not behind. When ice-bags are used, care is to be taken lest they should be too large; if so, they will not affect the desired spot at all. Small pieces of ice frequently swallowed are greatly relished by the patient; water-ices in small quantities will render the same service; ice-cream, in half-teaspoon or teaspoon doses every five or ten minutes, adds to the necessary nutriment. When the fever is high and the surface hot, sponging with tepid or cold water, or water and alcohol, will mitigate both. For the cold bath or the cold partial pack (trunk and upper part of the thighs) the general indications hold good. As a rule, I favor the latter, for many cases have such a tendency to debility and collapse that sometimes the circulation of the surface of the body is badly interfered with by cold bathing. Therefore, a contraindication to cold bathing must be found at once in cold feet, either before or after a bath. When, unfortunately, the feet do not recover their normal temperature in a very short time, they ought to be warmed artificially, and the cold bath not repeated. In such cases the cold pack, however, is still indicated. A linen or cotton cloth, large enough to cover the trunk and half of the thighs, is dipped in cold water, well pressed out, and the body of the patient wrapped tightly in it. The arms remain outside; the whole body is then wrapped up in a blanket; the feet may be warmed meanwhile when necessary, and the cold pack repeated as often as required to reduce the temperature—viz. once every five minutes, every half hour, every hour.

"The contraindications to the use of cold have in part been alluded to. Very young infants bear it but to a limited extent. The beginning of recovery contraindicates it, unless for some local cause; for instance, an inflamed gland. The extensive use of cold water or ice is also forbidden when there is no fever, where there is perhaps an abnormally low temperature, where we have to deal with the septic or gangrenous form of diphtheria, where the vitality is low and the mucous membranes pale or even cyanotic. In such cases, on the contrary, while unlimited internal stimulation is required, the hot bath or hot pack, and hot injections into the bowel, will be found beneficial."

"Chloride of iron is undoubtedly a valuable remedy in diphtheria, but in its administration it must by no means be forgotten that small doses at long intervals are out of the question. I have not the least doubt but that the failure of the remedy may be attributed in most cases to the fact that the doses were too small and administered too seldom. A dose of from five to fifteen drops, properly diluted, every fifteen minutes, half hour, or hour, is indispensable for a proper estimation of its effects. Gargles are not of much service, for the simple reason that they do not come into sufficient contact with the affected parts, and reach at the utmost to the anterior pillars of the soft palate. A direct application of the remedy to the

[1] C. Rauchfuss, in *C. Gerhardt's Handb. d. Kinderkr.*, iii. 2, 1878.

mucous membrane of the pharynx may also be desisted from, thereby avoiding any irritation, the internal administration at short intervals causing the pharynx to be sufficiently influenced by local contact with the remedy. It must, of course, not be expected that the chloride will remove the membrane, but it can frequently be seen to reduce the hyperæmia and swelling and prevent the reproduction of exuded material. The chloride of iron exerts a decided influence on the vital contractility of the blood-vessels. This increased contractility certainly assists in diminishing the rapidity of absorption of putrid fluids through the blood-vessels, which constitutes the principal source of danger from the disease.

"It cannot yet be positively asserted that the chloride of iron exerts a direct effect on the lymphatic vessels. Naturally, this was claimed when the remedy was recommended, in the treatment of diphtheria, on account of its therapeutic effects in erysipelas, with the accompanying inflammation of the lymphatic vessels of the skin. Although we know of no direct compression of the lymphatic vessels due to the action of the chloride, yet it may be assumed that perhaps the compression of the blood-vessels exerts a similar influence upon the neighboring lymphatics. In consequence of this there would be an impediment to the absorption and further development of poisonous substances in the lymph. The chloride, like the sulphate of iron, is a tolerably powerful disinfecting agent. If this observation be correct, it may go very far toward explaining the action of the chloride of iron in septic diseases, which are accompanied by an exalted activity of the lymphatic vessels and an increase of the white blood-corpuscles. Furthermore, Saase has endeavored to show that the ferrous salts possess the power of converting oxygen into ozone. They share this power with the blood-globules exclusively, and could hence, to a certain degree, supply a deficiency of the latter. Pokrowsky, too, has shown that iron increases the process of oxidation in the body by demonstrating that in health there is an elevation of temperature and an increase of the percentage of urea in the urine during its administration. In anæmic persons, to whom iron has been given for the purpose of increasing the amount of blood, the above phenomena may be observed before this object is accomplished. Thus iron appears to replace the blood-corpuscles to a certain extent. Now, in infectious disorders of the blood, where the red globules are perpetually menaced with destruction, it seems plausible that the preparations of iron should exert an antiseptic action.

"Finally, it has been found that of all the preparations of iron the chloride possesses the greatest power of stimulating the nervous system. Possibly this effect may be traced to an increase of the arterial pressure in the nerve-centres. It has been said that this effect has been vividly illustrated in certain forms of chlorosis. If this be true, iron would be all the more indicated in diphtheria, since it would act as a prophylactic against a series of nervous phenomena that so frequently present themselves both during and subsequently to the diphtheritic process. Thus it is that for many years the muriate of iron has constituted the main element, with me, of internal medication in most cases of diphtheria, both of the mild and the most dangerous septic type. A common formula is, for a child of two years,

℞. Tinct. ferri chloridi, f℥ij;
Potass. chlorat. gr. xx;
Aquæ, f℥v;
Glycerin. pur. f℥j. M.

S. A teaspoonful every fifteen, twenty, or thirty minutes.

"Carbolic acid exerts a powerful influence on the vitality of all living elements, and hence also on rapidly proliferating epithelium, which constitutes a part of the diphtheritic membrane. It is of great advantage for local use. Its local effect, undiluted or diluted with equal or larger parts of glycerin or alcohol, in shrinking and removing membranes, is sometimes very useful; in mild solutions in water ($\frac{1}{2}$, 1, or 2 per cent.) it is very efficient in nasal injections or for external applications or mouth-washes. Rothe's prescription for external use is carbolic acid and alcohol each 2 parts, water 10, tincture of iodine 1. Its internal administration to the extent of five to twenty grains daily, given largely diluted, in small and frequent doses, is of less positive value."

"*Local Treatment.*—The mechanical removal of the membranes is not permissible unless they are almost detached. It is best to avoid their being cast off, unless partly loosened membranes in the larynx or trachea afford an indication for an emetic. Scratching and eroding the mucous membrane of the neighborhood give rise to new deposits. Even after spontaneous elimination of a membrane a new one may be formed within a few hours.

"To cauterize a diphtheritic membrane or infiltration I consider wrong, unless I shall be able to do so thoroughly and to limit the action of the caustic to the diseased surface. Therefore potassa or chromic acid cannot be utilized, because of the impossibility of limiting its effect. Nitrate of silver and mineral acids can be restricted in their effects, but these are not sufficiently thorough, particularly as but few patients will consent to have the remedy applied properly. When I do cauterize, I prefer a mixture of equal parts of carbolic acid and glycerin or the undiluted acid. The membrane crumbles and falls off in pieces. Force must never be used. Where it would be required in the case of obstinate children mild washes must be employed instead of the caustic. Besides, the internal medication detailed above meets every indication. When there is a slight swelling of the lymphatic glands, cold water or ice applications are usually all that is needed. The latter should be made according to general indications. The glandular and periglandular swellings are less the result of an actual filling up with foreign matter than of secondary irritation. Ice has a happy effect in such cases, both on internal administration, in the form of frequent small quantities of ice-water, ice-pills, ice-cream, and iced medicaments, and also externally by ice-cold cloths or India-rubber bags filled with ice.

"In general, the treatment of the swelled glands must be both based on its causes and adapted to the present condition. The adenitis and peri-adenitis is of secondary nature, the irritation being in the mouth, pharynx, and nares. In these localities is where the main treatment is required. The sooner the primary affection is removed or relieved or rendered innocuous, the better it is for the secondary complaint. Frequent doses of chlorate of potassium or sodium, or biborate of sodium in mild doses frequently repeated, according to the principles laid down in another part of this article, mouth-washes, gargles, nasal injections with water, salt water, or solutions of disinfecting substances, are not only indicated, but highly successful."

ORAL SURGERY.

PART I.

BY LOUIS McLANE TIFFANY, M. A., M. D.

HYPERTROPHY OF THE GUMS.

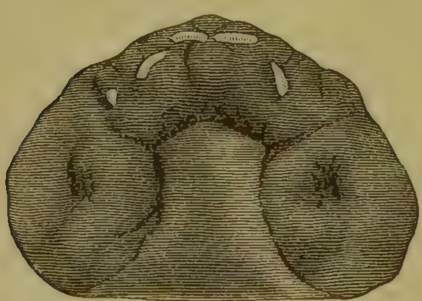
THIS rare affection was first described by Gross in the fifth edition of his *System of Surgery*. Since then several examples have been noted. The growth appears in early life, progresses slowly, and may conceal the teeth, almost filling the mouth. It has been associated with molluscum fibrosum, and the subjects of the disorder are usually of moderate intellectual power only. The gums appear as pink smooth or warty masses, covering in the teeth, which are usually more or less carious; the hypertrophied tissue may protrude from the mouth, distend the cheeks, or greatly fill the buccal cavity; to the touch the gums thus affected are elastic and firm, do not bleed easily, are insensitive, and where habitually uncovered by the lips may be somewhat like skin upon the surface. While both the upper and the lower jaws may be affected, the upper usually shows the most marked thickening; where a portion of the dental arch is diseased, the upper jaw is usually the seat of the lesion. Microscopic examination shows the fibrous stroma of the gum to be present in excessive amount, but no new glandular or epithelial elements.

The growth is classed as a true hypertrophy of the gum, but there is always also a more or less decided expansion of the alveolar border of the jaw. Salter's description of a case observed by him in the service of Mr. Pollock at St. George's Hospital is as follows: "In structure this hypertrophied mass consisted both of an expanded and a prolonged development of the alveolar borders of the maxillæ, and an immense thickening of the fibrous tissue of the gum, with a proportionately exuberant growth of the papillary surface. The removal of portions of the mass by surgical operation gave opportunities of examining its precise nature. In the front of the upper jaw, where the development was greatest, the fibrous mass extended in some places more than three-quarters of an inch beyond the alveolar edge, which it thus covered in with a dense cushion. Those of the temporary teeth which had not been extracted were deeply imbedded in the mass, the crowns of the second lower temporary molars being the only ones which were now visible. The crowns of all four of the six-year-old teeth (first permanent molars) had appeared on account of the slightness of the hyper-

trophy toward the back of the mouth. A section of parts of the removed mass displayed the remaining temporary teeth completely clothed with the thick fibrous growth, the fangs imbedded in sockets, but the crowns free of bone and each closely surrounded by a serous-like chamber without any communication with the surface. One of the superior central incisors was more deeply covered than other teeth, and was nearly an inch from the surface. The fangs of the permanent teeth were developed in accordance with the age of the patient, but I observed that the crowns were still encased in the bony loculi, though from the age of the patient the distal wall of the bony capsules should in many of them (incisors and premolars) have been absorbed. In the socket of the first temporary incisors a small absorbed orifice existed leading into the loculus of the permanent tooth, such as is usually found about five years old. But the most remarkable point of structure in this growth was the papillary surface. The epithelium had changed into a very thick and hard epidermis, beneath which, and evenly covered in by it, were enormously long papillæ. The papillæ of gum vary from about one-seventy-fifth to one-thirty-fifth of an inch in length, normally, but in a section vertical to the surface they here appear from one-sixth to one-fourth of an inch, and when by maceration the outer epiderm has been removed the papillæ stand up like the pile of plush or velvet, and may be brushed from side to side by the finger."

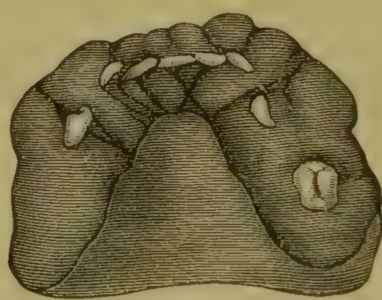
The association with fibroma molluscum is not accidental, and the two affections are the result of a cause not yet discovered. No pain is caused by the growth, and inconvenience results from its size as well as from inability to masticate; in an extreme case fluid food only can be taken by the patient.

FIG. 149.



Upper Jaw.

FIG. 150.



Lower Jaw.

Hypertrophy of Gums (Heath).

TREATMENT.—No medication in any way modifies this disease. Removal of the hypertrophied gum, together with the alveolar border of the jaw, will effect a cure. This is best done by strong cutting-pliers, and Paquelin's cautery will arrest any hemorrhage that firm pressure with a hot sponge does not. Excision of the hypertrophied gum only, the alveolus being spared, does not give a favorable result. After recovery an artificial denture can be adjusted. To avoid useless repetition of the details of operative measures within the mouth involving much hemorrhage, the reader is referred to p. 582, Excisions of Jaws.

Localized hypertrophy of the gum from irritation is not infrequently

seen, lack of cleanliness or accumulation of tartar being the exciting cause. The alveolar border between the teeth is the chosen seat of this lesion. Strict attention to the proper hygiene of the mouth will generally cause a subsidence of the hypertrophy; this failing, however, excision is required, which in cases of exceptional gravity must include the edge of the alveolus. Papillary hypertrophy, pedunculated or sessile, not connected with the teeth, has been met with, and strongly recalls in aspect the venereal wart; it is in no wise, however, the outcome of syphilis, though the cause is still unknown. Such a growth has been found on the hard palate.

FIG. 151.

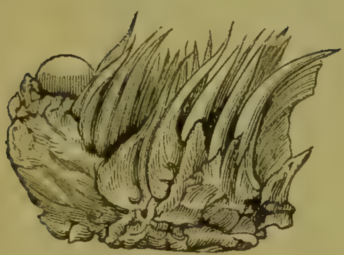
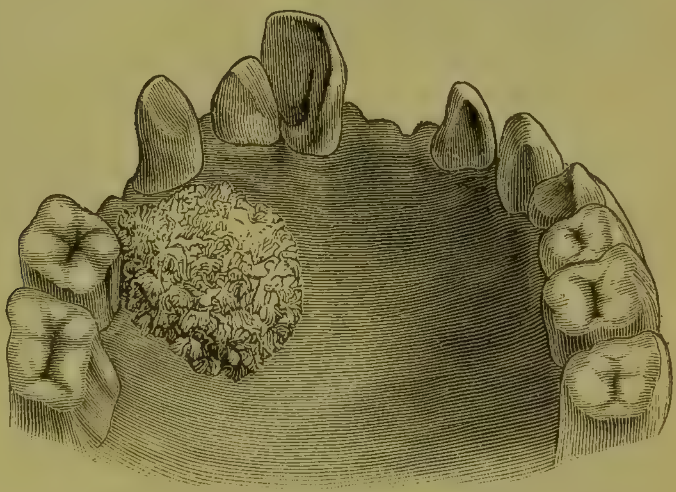


FIG. 152.



Papilloma of the Gum (Heath).

The TREATMENT is free erasion with a Volkmann's curette: oozing from the bone is best arrested by the application of tannin or powdered subsulphate of iron. Vascular growths, nævi, are developed from the gum, in my experience usually on the labial surface; they are recognized by the same signs that accompany their presence elsewhere. The application of a strong solution of tannin will occasionally induce shrivelling, but by the use of Paquelin's cautery a cure can certainly be induced. In 1885, I had under my care a patient with an extensive port-wine mark on the left side of the face; the inside of the left cheek was not similarly affected, but the labial surface of the gum of the corresponding upper jaw was. A fibrous tumor developed from the bone beneath the angeioma, and was excised, yet the resulting hemorrhage called for no comment.

Epulis is a term often employed to indicate a tumor of any kind growing from, or in connection with, the gum. The term has no anatomical meaning, and should be abolished and the usual classification of growths substituted.

Fibrous tumor of the gum is generally sessile, grows from the periosteum of the alveolar border, and commences usually just within a tooth-socket. Growth is slow and painless, rarely being so marked toward the buccal as the labial surface. Discomfort results from pressure upon neighboring structures and interference with their function. The patient discovers the growth by accident in most cases, as no pain

is experienced. Unless operated upon, continuous increase is to be expected, and the growth may reach a great size. The tumor is smooth, rounded, perhaps lobulated, firm, somewhat elastic, covered by oral mucous membrane of natural color, is not prone to cystic degenera-

FIG. 153.

Fibro-angeioma (Agnew).

FIG. 154.

Fibrous Tumor from Gum (Bryant).

tion, and may displace the teeth by pressure. No treatment save excision is to be thought of: as the periosteum and subjacent bone-surface are involved, they should be removed with proper forceps and gouge. The tumor is benign and does not recur.

Other benign growths originate from the jaws and involve the gums secondarily. Malignant tumors also extensively infiltrate adjacent parts: it will be best to consider both subjects under the head of Tumors of

FIG. 155.

Epulis" (Liston's case).

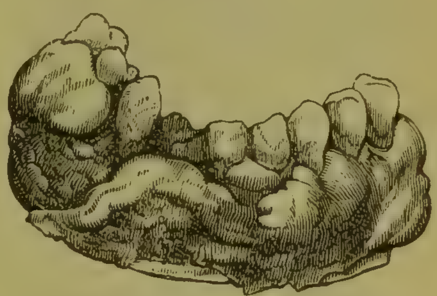
the Jaws. The pernicious habit, already alluded to, of styling all new formations in any way involving the gum "epulis," cannot be too much reprobated, as liable to greatly mislead, since the word indicates neither clinical nor histological peculiarities.

There are two varieties of new formations occasionally met with on the gum, to which it is worth while to call attention, as an early diagnosis is important—gummy tumor (tertiary syphilis) and epithelioma.

Gummy tumor is met with as a small nodule adjacent to a tooth, rapidly breaking down and leaving an ulcer of irregular oval shape with "worm-eaten" borders somewhat raised, the base yellow, somewhat depressed below the surface of the healthy gum, with occasional red granulations showing.

Epithelioma first attracts attention as an indurated plane, somewhat raised, with eroded or ulcerated surface about the centre. There will be found, usually, a source of irritation—a decayed tooth, for instance—adjacent to the ulceration. A patient was under my care some time since who developed an epithelioma at the place where he habitually carried a "chew" of tobacco—namely, the gum over the lower jaw toward the cheek. Pain is often a prominent symptom. Base and edges are pink; extension is apt to be along the jaw rather than toward the tongue or the cheek. The lymphatics may early be involved, while in tertiary syphilitic lesions such is not the case. The differential diagnosis between the two affections in their incipiency is greatly assisted by a course of antisyphilitic treatment. In not a few cases epithelioma of the gum has commenced at a point irritated by the pressure of an ill-fitting artificial denture. Treatment is simple, but, owing to delay on the patient's part, a cure is not often obtained: free removal of the affected gum and adjacent bone with cutting forceps is to be resorted to, and if necessary the further application of chloride-of-zinc paste.

FIG. 156.



Epithelioma of Gum (Fergusson).

AFFECTIONS OF THE HARD PALATE.

The hard palate is so closely allied to the gums in structure as to offer but little difference from a pathological standpoint. Agnew has described in two instances a local gangrene affecting one lateral half of the palate: both cases were rapidly fatal, in five and six days respectively, the symptoms being those of septicæmia: embolism of the posterior palatine artery was believed to be the cause. Cartilaginous, fibrous, and adenoid growths are the most frequent of non-malignant tumors, but are extremely rare. They are easily enucleated after free division of the overlying mucous membrane. Some years ago I removed with the chisel an osteoma from this situation. The tumor was oblong, extending across the palate from the left cuspid. I undertook the operation of removal, thinking that I had to deal with a misplaced tooth, but the growth was bone throughout. Heath records two cases of small-celled sarcoma—one his own, the other in the practice of Fergusson—occurring on the palate. Epithelioma in this region is more frequent, however, and may be an extension from the neighboring gum, or, what is perhaps still more frequent, from the antrum.

This latter disease is very insidious, perforating the palate and appearing in the mouth only after extensive implication of adjacent structures has taken place. Removal of such a growth involves a very extensive operation, one or both upper jaws requiring resection. Should the growth have begun in the buccal mucous membrane, thorough curetting with Volkmann's spoon, followed by free application of nitrate of silver in substance, may effect a cure.

Malignant growths of the bony palate will be considered under the head of Upper-jaw Tumors. Syphilitic ulceration with perforation of the hard palate is often seen. The affection is one of the later lesions of pox, and commences as a gummy infiltration of the mucous membrane; softening occurs, pus is discharged, disclosing bone which necroses; after separation of the dead bone a perforation into the nasal cavity is apparent. The ulceration is usually near the middle line of the body, and exceptionally so far forward as to involve and destroy the sockets of the incisor teeth. The alveolar border of the jaw save at this point does not seem to be subject to syphilitic necrosis.

Affections of the Soft Palate.

The soft palate may be the seat of sebaceous, dermoid, adenoid, or fibrous growths presenting symptoms after their kind and requiring excision. Several instances of pedunculated fibroid have been recorded, the growth being attached to the upper surface of the soft palate and hanging into the fauces and œsophagus. Muciparous cysts are occasionally met with, presenting the appearance of drops of water imbedded in the mucous membrane. They are cured by a single application of nitrate of silver after incision and escape of contents.

Sarcomata in this region are met with very rarely; carcinoma, however, is, unfortunately, not infrequent; epithelioma is the variety commonly met with. Epithelioma usually commences near the pillars of the fauces, extends toward the middle line of the palate, and also downward along the pillars toward the epiglottis. Symptoms indicating the gravity of the affection are at first wanting, and later, when a diagnosis is reached, the time for successfully coping with the neoplasm has passed. It is wellnigh impossible to differentiate by inspection between a commencing epithelioma and a syphilitic ulceration, the more so as the former may originate in a scar remaining after the latter; in such a case the effect of an antisyphilitic course of treatment becomes necessary before a diagnosis is possible. A septic pneumonia with fatal result may occur at any time during the existence of an epithelioma of the palate or pharynx. The treatment of carcinoma in this situation necessitates some of the most extensive operative measures about the face and neck now known; for particulars of which the reader is referred to a treatise on general surgery.

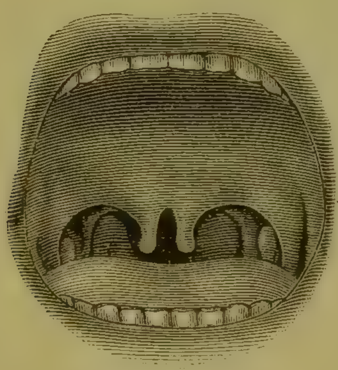
Perforation of the soft palate is not infrequently seen in the later stages of syphilis, and is disastrous in effect. Early symptoms may be overlooked: a gummy infiltration, either circumscribed or diffuse in the velum, occurs without pain, and the patient's attention is attracted about the time that the softening commences. This advances rapidly: a cavity

with sharply-cut, irregularly-rounded edges is formed, and perforation occurs; speech and deglutition are greatly impaired, and unless the destructive process is arrested a large part of the velum may melt away, as it were. A nasal tone of voice and regurgitation of liquids through the nose characterize the progress of the malady. An early diagnosis and vigorous antisyphilitic treatment are indicated. An interesting sequel is occasionally seen—namely, adhesion of the velum to the back of the pharynx, thus cutting off the nasal cavity and upper pharynx from the mouth. Surgical measures have not yet succeeded in entirely overcoming this adhesion of the velum to the posterior wall of the pharynx, when once established.

Cleft Palate.

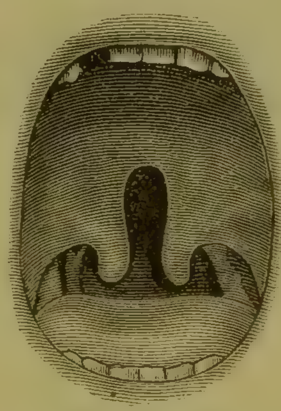
The upper jaw is developed in four well-marked segments—two large lateral portions, the maxillary bones, right and left; two small portions,

Fig. 157.



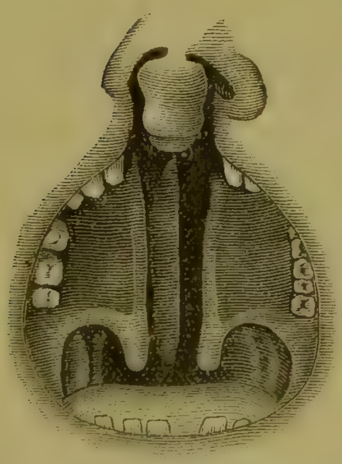
Cleft Uvula (Mason).

Fig 158.



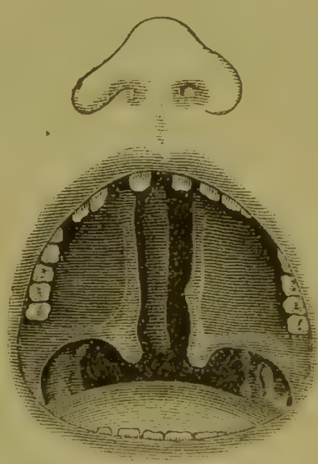
Cleft of Velum (Mason).

Fig. 159.



Cleft of Hard and Soft Palate: rudimentary intermaxillary bone placed in advance of lips (Mason).

Fig. 160.



Cleft of Hard and Soft Palate (Mason).

the right and left intermaxillary bones: these latter carry the incisor teeth; all the other teeth grow in the maxillary portions. One or both intermaxillary bones may not develop, and a fissure will then exist in the

upper jaw at birth. To this deformity the term cleft palate is applied. The condition is often associated with a corresponding failure of the lateral halves of the lips in front and of the soft palate behind to unite in the middle line. The extent of the malformation varies greatly according as the fissure involves the lips, the alveolar border of the jaw, the hard palate, the soft palate, or, involving all the structures, transforms the mouth, nose, and pharynx into one chasm. The cleft may exceptionally extend to, and involve, the base of the skull. Fissure of the bony palate, the velum remaining normal, is very rare. From the above it will be seen that single cleft palate occurs to one side of the middle line, corresponding to one intermaxillary bone, and occupies the middle line only when both intermaxillary bones are undeveloped. Under such circumstances the premaxillary bones are fused together as an irregular knob—carrying, however, the four incisor germs—which is attached to the vomer or to the nasal septum, and may project far in advance of its natural position: the incisors are of course misplaced.

Fig. 161.

Double Hare-lip and Cleft Palate, the intermaxillary bone carrying four incisors.

In the discussion of cleft palate no reference has been made to the part which the palate bones play in the subject; this omission is intentional, and the palate bone is treated as one with the maxilla: to speak of it as a separate entity would confuse the subject in hand and be scarcely more accurate.

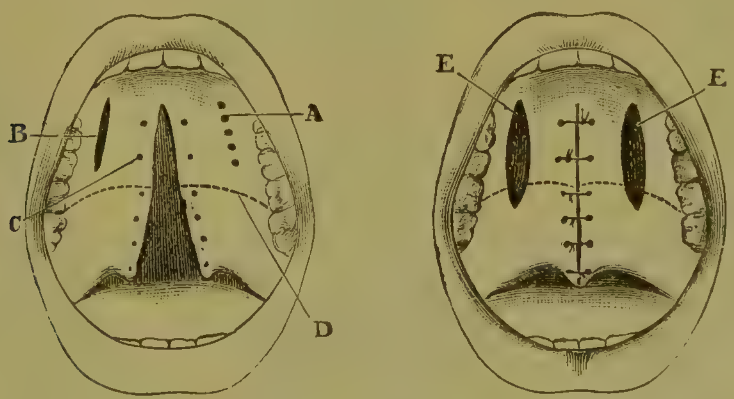
Treatment.—The treatment of cleft palate does not consist simply in closing the bony roof of the mouth and reconstructing the velum. The operation is undertaken in order to facilitate and improve speech: correct speech is an acquired art, and closure of a fissured palate unaccompanied by vocal exercise is an incomplete and indifferent operation. Repair of a hare-lip, which must always precede a cleft palate operation, will lessen the breadth of the palatal fissure, and while this closure is taking place careful and methodical exercise in speaking must be daily practised. Great improvement can be effected in this direction *before* operation. The very different results obtained by different operators must depend, I think, somewhat upon the training of patients after as well as before operation. After closure of the fissure the same careful vocal gymnastics must be practised, for the repaired velum is a tense screen, not the elastic speaking-curtain of the normal mouth. The age at which fissure of the soft palate should be closed will depend somewhat upon the intelligence of the individual: too soon, the child will not have had sufficient training; too late, vicious methods of speaking will be firmly settled. Between the ages of ten and sixteen generally appears to be the most suitable period; the older the patient the more

assistance he can afford the surgeon, and an anæsthetic may be dispensed with; with young children anæsthesia, as well as a gag to keep the jaws open, will be required.

Uranoplasty.—The operation for closure of a cleft in the hard palate is termed uranoplasty. J. Mason Warren first devised and executed it. Warren raised flaps of mucous membrane from either side of the fissure and brought them together by suture, thus bridging the chasm. Langenbeck modified this method by raising the periosteum with the mucous membrane, hoping that a plate of new bone would be formed by the transplanted flaps. The operation is as follows: The edges of mucous membrane at the fissure are freshened; an incision down to bone is carried close to the alveolar process from just outside the posterior palatine foramen as far forward as may be necessary; the soft parts between these incisions are raised from the bony palate, slid together in the middle line, and united accurately by a suture. The attachment of these flaps to the posterior edge of the hard palate is very intimate, and may need complete and careful separation; the bleeding also is apt to be free, but pressure will quickly control it. As it is usual to attempt to close fissures in both hard and pendulous palates at one operation, clearing the posterior edge of the hard palate enables the velum to be more easily drawn to the middle line. Sutures may remain undisturbed during five or six days according to the tension of the flaps.

Fergusson has modified the above operation by dividing the bony palate with a chisel along a line corresponding to Langenbeck's incision, and then moving the flaps—containing, of course, bone—to the middle, where they are united by suture. To facilitate cutting the hard palate,

FIG. 162.



Fissure of Hard Palate: *A*, preliminary punctures with awl to give line for chisel; *B*, incision through bone completed by chisel; *C*, holes bored through hard and soft palates for sutures; *D*, junction of hard and soft palate; *E*, lateral openings subsequently filled up by granulation (Bryant).

Mason has suggested perforating the bone along the line of division before using the chisel—a measure of undoubted merit. In the young child, by using a strong clamp, it is possible to press together the halves of the upper jaw, thus closing the cleft, when the edges may be united by suture.

When the palatal fissure is unilateral, the method devised by Lannelongue offers an easy way for closing the gap. Lannelongue separated a large flap of muco-periosteum from the side of the vomer, leaving it

attached below, and then secured it by suture to the freshened edge of the cleft.

Staphylorraphy.—The operation undertaken for the purpose of closing a cleft in the soft palate is termed staphylorraphy. The fissure is median, and involves all structures, even the uvula being divided. One would suppose that it would be easy to denude and stitch the two halves of the velum together, so that they would unite; such, however, is not the case. Certain muscles entering into the velum pass from the median line outwardly, and render it tense; when, therefore, it (the velum) is fissured, the muscles by their action separate the two halves of the soft palate. As breathing, swallowing, etc. throw the soft palate into action, the difficulty of keeping it quiet long enough for its halves to unite after an operation is very apparent. The muscles especially concerned in separating the edges of the cleft are the tensor palati, levator palati, palato-pharyngeus; for a description of which muscles the reader should consult Vol. I. p. 195 *et seq.* It is essential for the success of the operation that these muscles should be divided: the velum is then at rest, and by the time that the muscles have reunited the adhesion between the halves of the palate is firm.

The various steps to be pursued in the operation of staphylorraphy are—1st, denuding the cleft; 2d, passing the sutures; 3d, dividing the muscles; 4th, closing the gap by tying the sutures. The operator with strong forceps grasps the uvula of one side, and with a slender sharp knife shaves off a ribbon of tissue from the inner edge of that half of the curtain, cutting upward or downward according to fancy. The velum is thick, and it is a mistake to denude sparingly; broad raw surfaces must be prepared for apposition. Sutures of silk are to be passed

Fig. 163.

Fig. 164.

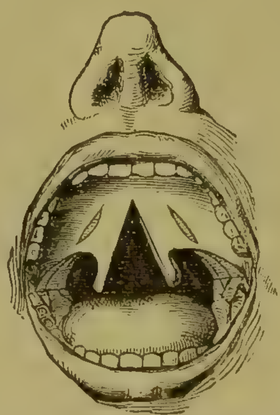


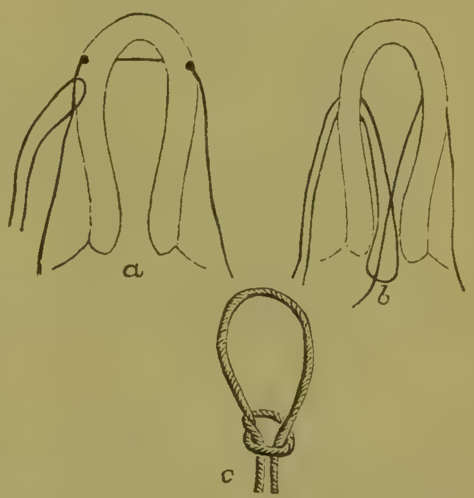
Fig. 165.

Sédillott's Operation for Staphylorraphy.

through the velum, so that the knot when made shall lie on the lingual surface; they should be long enough to pass out of the mouth and be held out of the way until tied, and should traverse the velum three-sixteenths of an inch from the denuded edge of the fissure. Different operators follow different methods for passing the sutures, using needles of varying shapes. I vastly prefer Langenbeck's needle to all others, and use it always. When the sutures are in position, I pull upon them to render tense the velum, so as to divide the muscles. Drawing one-half

the soft palate downward and inward, the tensor and levator palati are rendered tense to both sight and touch; a slender knife is then passed through the velum close to the inner side of the hamular process, and made to cut upward and inward about half an inch: this will probably be sufficient to effect division of the tensor. Should the velum not hang freely by traction on the ligatures, I can recognize any resisting structure, and do not hesitate to divide it by transfixing the soft palate. The palato-pharyngeus and palato-glossus I have usually found it necessary to divide: I have done it most comfortably with a pair of angular blunt scissors having rather long handles. The soft palate must be separated from the hard for a short distance on each side of the cleft, otherwise the soft curtains will not come together at the top. The fissure pared, sutures passed, and muscles divided, it remains but to tie the stitches. This is best done by making a loop in one end of a suture and passing the other end through it, as shown in the illustration (Fig. 166, *c*). By traction on the untwisted end the loop passes up against the palate, and a little further traction secures coaptation; a second knot renders everything secure. Sutures should be a quarter of an inch or three-sixteenths of an inch apart, and should not be tied so tightly as to strangulate the contained tissue; light and easy, not tight, apposition is to be obtained. Wire secured by shot is preferred by some operators. Alternate sutures are to be removed on the third day usually, and the others a day or two later. It is most important to secure union between the lower ends of the curtains, for if this is gained the upper portion can usually be left to granulation; stimulation by nitric acid may be required. After-treatment consists largely in keeping quiet the velum until repair is assured: for several days the patient must not talk, may take fluid only as nourishment, and may eat small pieces of ice. When the curtain is firmly repaired, then methodical and careful vocal exercises are to be practised, being mindful that the patient is putting in use an entirely new organ not hitherto possessed, and that he will therefore be somewhat awkward.

Fig. 166.



Staphylorraphy: Passing the Sutures: *a*, Suture Passed; *b*, Loop; *c*, Knot (Stimson).

Hare-lip.

This term is applied to the deformity resulting from a failure of the lateral portions of the upper lip to unite, and is to be considered in connection with cleft palate, with which it is frequently associated. The term "hare-lip" is derived from the supposed resemblance existing between the deformity in question and the lip of the hare, and conveys a wrong impression, since the division in the latter is always in the middle line.

The fissure in hare-lip corresponds with the position of one or both intermaxillary bones, being called single or double as the case may be: when single the cleft is apt to be to the left. The fissure may be so slight as only to notch the lip, or may extend into the nostril, with accompanying palate deficiency to a greater or less degree. When the fissure is single, the lip forming the inner border is continuous with the septum of the nose, is connected with the gum by a normal frænum, and lies in a plane somewhat anterior to the lip, forming the outer border of the fissure, which is continuous with the ala of the nose. The mucous membrane of the nose is continuous with that of the lips along the edges of the fissure. The prominence of the alveolar border supporting the inner edge of the fissure is sometimes so great as to seriously complicate any attempt to repair the deformity.

Double hare-lip holds the same relation to single hare-lip that double cleft palate does to single cleft palate, the main difference being that the median portion in hare-lip is generally capable of being utilized for repair of the deformity, which is not the case in cleft palate. In double hare-lip the two fissures correspond to the intermaxillary bones in position, each cleft resembling that met with in single hare-lip. Reference has already been made to the extreme displacement of the intermaxillary bones occasionally seen, as the median portion of the upper lip follows these bones in their malposition: that a most complicated condition of affairs may be present is easily understood. It may be truly said that hare-lip is a great or small deformity and easily or with difficulty repaired according as the upper jaw is properly or improperly developed. It will sometimes be the case that the fissure does not follow the classical lines, so to speak, referred to; thus, it may extend into the cheek or up through the lower eyelid; but these are instances of variation in degree only.

Fig. 167.

Fig. 168.

Fig. 167. Uncomplicated Double Hare-lip.
Fig. 168. Double Hare-lip complicated with Fissure of Alveolus and Projection of Intermaxillary Bone, the Palate being Perfect (Bryant).

Treatment of Hare-lip.—The operative measures undertaken for repair of a fissured lip must be decided by the exigencies of each case. There is no such thing as "the best hare-lip operation;" each case is to be carefully studied, and the method employed which shall appear suitable for the anatomical peculiarities present. Certain general rules are to be thought of in all hare-lip operations, and demand consideration.

The fissured lip is to be closed as soon as possible after birth, but very young children bear loss of blood badly, and may be not well nourished from inability to suckle: it is well, therefore, to delay operation until all the child's organs are working well; the greater the deformity to be cured, the more strength will be needed to recover from the operation. If necessity requires, the operation can be undertaken shortly after birth; it is, however, better to wait a few months. It is well to

remember that the tension of the restored orbicular muscle of the mouth tends to close a cleft in the hard palate, and the softer the bones the more easily is this change effected; hence an early operation is expedient.

The mucous borders of the cleft must be removed and the raw surfaces united by suture, but the lip is already too short; hence as little tissue as possible is to be removed, and when practicable flaps are to be made and utilized for repair instead of being entirely severed. It is found by experience that if the parings are used to form a prominence

Fig. 169.

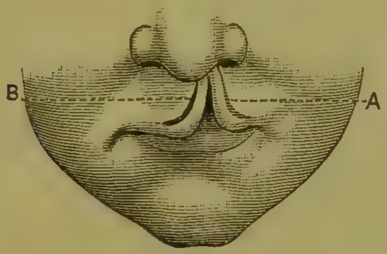


Fig. 170.

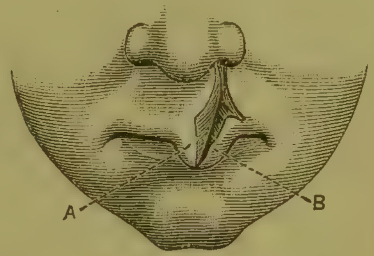
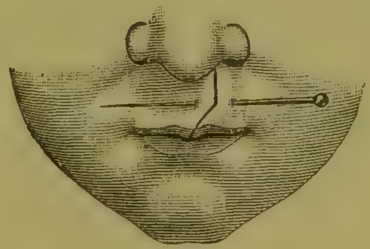


Fig. 171.

Fig. 172.



Operation for Hare-lip (Bernard and Huette).

at the lower border of the scar, this prominence gradually sinks to the proper level, while if the lip is at first evenly restored, the tension of the orbicular muscle causes a stretching of the scar at the lower end, and the line of the lip is, sooner or later, broken by an irregularity in the shape of an inverted V; thus, Λ.

The vivified sides of the fissure are to be made to lie together without tension: this is the most important part of the operation. It is to be brought about by very freely dissecting the lip and cheeks from the upper jaw. It is difficult to conceive of too free a dissection, so necessary is it for success. From the whole alveolar border I have repeatedly separated the lip and cheeks, and always with advantage.

The treatment of a protruding intermaxillary bone varies with the amount of displacement. The restored lip must not rest upon a sharp edge; hence in single hare-lip with cleft palate the alveolar edge which advances beyond the line of the arch is to be forcibly pressed back: a strong pair of forceps will usually be sufficient for the purpose; if not, then the border of the bone is to be cut with pliers and the protrusion reduced. If thoroughly replaced in position, the pressure of the restored lip will suffice to retain it there. If double cleft palate complicates double fissure of the lip, the nodule of bone representing the joined premaxillæ may be situated most irregularly, as already referred to. Many methods have been employed to press the nodule into the cleft of the alveolar

border, and usually success is attained; but pressing this bone backward changes its relation to the rest of the jaw, and the incisor teeth, the germs of which are developed in the premaxillæ, grow most erratically, and usually have to be extracted. It is generally best to remove the nodule of bone, with its incipient incisors, preserving the periosteum and mucous membrane to be utilized as a support for the restored lip. Pin suture is the classical means of securing accurate union of the cleft edges: if there is no tension at the line of union, almost any suture will suffice. Sutures may remain for several days undisturbed.

Restoration of a lip restores function; improvement in appearance and change of shape in the face go on, however, for a long time.

Hereditary predisposition is marked in certain cases.

That it is not expedient to operate for cleft palate and hare-lip at one sitting is plain, owing to length of time required, but it is usually best to attempt the closure of the hard and soft palates at one operation, subsequently closing any points which have failed to unite.

Where the edges of the cleft are brought together with some tension, it is my habit to pass through each cheek the end of a wire suture, catching it to a flat button, thus forming a relaxation suture and taking all strain from the line of union. By letting the button rest on thick adhesive plaster, injury to the skin is avoided. The wire passes in front of the cleft alveolus, and aids in retaining the intermaxillary projection in position.

Diseases of the Antrum.

Inflammation of the antrum is not met with as an idiopathic affection; it occurs as the result of injury and as an extension from a diseased tooth. The first or second molars are the teeth most likely to act as the exciting cause, as their fangs project into the floor of the antrum: a foreign body may be the exciting cause. The usual symptoms of inflammation are not always present, and the onset of the disease is apt to be insidious unless the opening into the nose is closed: a catarrhal inflammation of the lining membrane expresses the pathological condition present; a sense of distension and weight in the upper jaw will be complained of, which is relieved by discharge of pus; pus will flow on lying down on one side, and will be noticed in the nose or throat intermittently; a bad taste or smell may be complained of. The amount of pus passing into the throat and swallowed may be so great as to induce nausea or ill-health. Should the opening into the nose be closed, the symptoms of retained pus become evident—pain, fever, rapid pulse, distension of the antrum and absorption of its bony wall, perforation and sudden discharge of pus, with immediate amelioration of symptoms. Both antra may be affected. An eye may protrude greatly from antral distension, and the inflammation may extend and involve the meninges. The diagnosis offers no difficulty.

Treatment is simple and rapidly efficacious. The cause, usually a carious tooth, is to be removed; the antrum freely opened through the diseased socket, and kept clean by frequent and copious syringing. The opening should not be less than one-fourth of an inch in diameter, and

the entrance of food may be prevented by a proper obturator, which will serve likewise as a means of keeping the opening patent. When the antrum is distended by retained pus, and the surgeon fails to recognize disease of any tooth, the second molar may be extracted, the antrum freely perforated through the socket, and washing commenced. Inspissated pus may fill an antrum and simulate a solid tumor: it will, of course, have been present a long time, and is to be evacuated by incision above the alveolus, the cavity being washed out frequently. When suppuration is persistent, the antrum is to be opened by incision and the cavity explored by touch: a fang or a misplaced tooth may be discovered, and should be removed. One or more of the glands of the lining membrane of the antrum may undergo cystic degeneration, giving rise to the so-called dropsy of the antrum—hydrops antri. The fluid is usually clear, may be thin or viscid and thick; cholesterin is present in decided quantity. The gradual distension of the bone is marked in all directions, and when handled the bone may crackle like parchment. The disease advances slowly, is painless, and not dangerous.

TREATMENT.—A cure is obtained by freely opening the antrum and cyst: after evacuating the contents, a drainage-tube and stimulating injections induce rapid healing.

Epithelioma of the antrum is a most insidious disease: it involves much surface before being discovered, and is difficult to eradicate. It has been described in France under the name *épithéliome térébrant.* A molar may become loose, and, being extracted, the finger passes into the antrum, which is lined with epithelioma growth; or a wart appears upon

FIG. 173.

Epithelioma of Upper Jaw, showing villous growth (Heath).

the hard palate, which is gradually destroyed, permitting the finger to pass into an antrum the walls of which are of malignant growth. The only instance of this form of growth which I have seen occurred in a male aged fifty-five years: the antrum was filled with cancer, and a cancerous mushroom-like formation was attached to the roof of the mouth; yet the palate was not perforated.

This variety of growth is met with in people of middle or advanced life, and treatment to be successful must be radical: the jaw must be removed, or else, a free opening being made, the morbid tissue is to be scraped away and chloride of zinc applied, and the application repeated if deemed expedient.

Other antral tumors will be considered with Upper-jaw Growths.

Cysts connected with the Teeth.

Cysts are met with in connection with either the fully-formed or the undeveloped teeth: in the latter case they are termed dentigerous cysts. They may be found in either jaw, but when in the upper jaw and of any size are apt to be mistaken for antral cysts. With rare exceptions they are seen in connection with the permanent teeth. Occasionally, connected with the fangs of permanent teeth are cysts so small as not to give rise to symptoms, they being discovered only after extraction for some other cause: the contained fluid may be rich in cholesterin and thickish. Broca believes that cysts of the jaw arise from teeth-follicles.

Fig. 174.

Dentigerous Cyst of Lower Jaw (Heath).

Growth is slow and painless; the bone surrounding the cysts is gradually expanded, and by absorption becomes very thin or entirely disappears; neighboring structures are displaced until an extreme degree of deformity results; occasionally, though rarely, a firm shell of bone surrounds the enlarging cyst, thus simulating a solid growth: usually, however, fluctuation can be obtained at some point through the thinned bone. The contents of the cyst will be clear fluid, more or less brown in color. The diagnosis rarely offers difficulties, and is promptly made by an incision. The treatment is to open freely, remove, if necessary, a portion of the bony wall, and ensure granulation with subsequent contraction. The operation is to be done from within the mouth, so as to avoid scar.

Cysts connected with undeveloped teeth are more often seen than the variety just referred to. They may occur where teeth are usually found, or elsewhere in the jaws, as the ramus of the inferior maxilla or between the plates of the palate process. They are believed to originate from the enamel-organ, and almost always from that of a permanent tooth. A supernumerary tooth exceptionally serves as a starting-point. The tooth in relation with which the cyst develops may be turned and grow in a wrong direction, or may be entirely misplaced and completely covered by bone. Even though the proper number of teeth are present, careful examination may show that a temporary fills the place of a permanent tooth. The tooth at fault always projects into the cyst, and after free incision a finger introduced through the wound will find it. More than one cyst may be present. Baum saw a cyst in each antrum, a

molar and a cuspid being respectively the exciting causes. The antrum may be opened into, and is frequently pressed upon and partially obliterated, so that less swelling is noted in the upper than in the lower jaw: in this latter situation deformity is very marked. Legouest's case pulsated, owing to the vascularity of the covering membrane. Suppura-

FIG. 175.

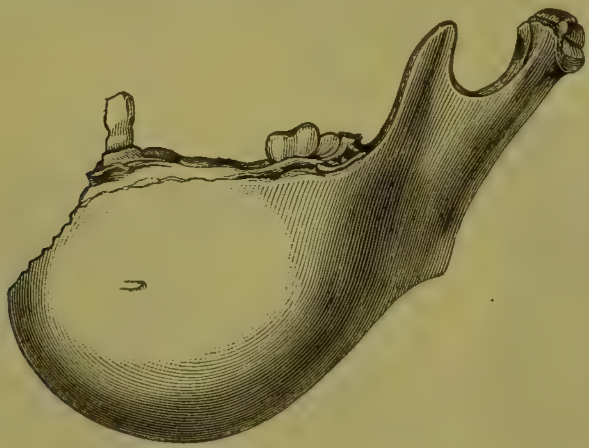


FIG. 176.

Dentigerous Cyst of Lower Jaw (Heath).

tion and intermittent discharge, with corresponding exacerbation of symptoms, may be seen, and cease only after removal of the cause. Growth is slow and painless; the thickness of bone covering the cyst will vary, permitting fluctuation to be felt, or, on the other hand, simulating a solid osseous growth.

The diagnosis will rest mainly on the rate of growth, sense of fluctuation, absence of pain, and, most important of all, absence of a permanent tooth. The diagnosis is rendered certain by incision and exploration with the finger.

It is a wise procedure to cut open apparent bony tumors of the jaw before extirpation, as a dentigerous cyst with a thick bony envelope is very difficult of diagnosis, and may induce a needlessly severe operation.

The treatment to be adopted is simple, free incision into the cyst with chisel if necessary, and removal of the misplaced tooth: the cavity will then heal by granulation; injections to be used if required. All cutting is to be done through the mouth, so as to avoid scar.

Within the past month I have operated upon a dentigerous cyst developed about a permanent cuspid tooth which was situated in the

nasal process of the right upper jaw. The patient was eight years of age, and had noticed the swelling during the past year.

Solid Tumors connected with the Teeth.—Displacement of a tooth has been shown in the preceding section to be a frequent cause of cystic formation : it will sometimes happen, however, that malposition gives rise to an osseous growth, or that a tooth may develop almost normally, but at a distance from its proper situation. When located in the alveolar border of a jaw, a diagnosis may be reached, but when a tooth is found, for instance, in the floor of the nasal fossa, as recorded by

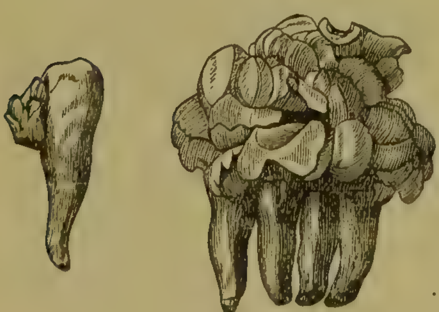
FIG. 177.

Forget's Case.

Forget, recognition is most difficult. The upper jaw is more liable than the lower to these displaced teeth, and the wisdom tooth is often at fault. Probably the most singular example of this variety of osteoma is recorded by Tomes as having been observed in India. The patient presented a large solid growth of the upper jaw containing fifteen malformed teeth ; the tumor projected forward, producing great deformity of the face.

A misplaced tooth may induce excessive growth of bone, the tooth itself being the nucleus of the tumor. In such a case a diagnosis could be arrived at only after removal and section of the osteoma.

FIG. 178.



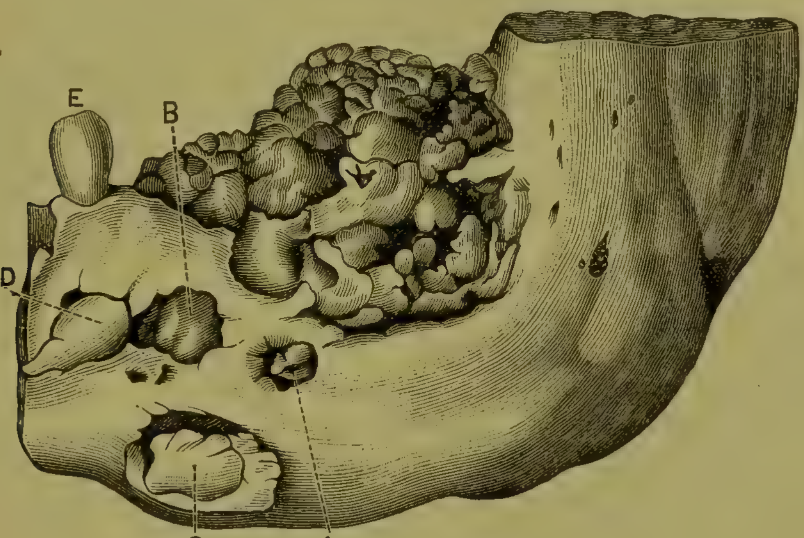
Warty Teeth.

Our knowledge of tumors composed of the constituents of the teeth rests mainly upon the researches of Broca. The three classes described by him and worthy of mention here are coronary odontoma, bulbar odontoma, radicular odontoma.

Coronary Odontoma.—This is an outgrowth from a perfect tooth, and is supposed to be due to a modification of the dentinal pulp after capping. The so-called warty teeth (Fig. 178) are examples of this class.

Bulbar Odontoma.—Only nine or ten cases of this class have been recorded. A modification of the tooth-germ before being capped by dentine produces the growth, which consists of a hard mass of cementum, enamel, and dentine irregularly laid together, in shape not resembling a tooth at all. Annandale's case[1] may be taken as a type of the class under consideration. The patient was a female aged seventeen years, whose left lower jaw was without molar teeth. A nodulated mass resembling a piece of necrosed bone protruded through the gum, and was firmly fixed. It was removed through the mouth,

FIG. 179.



Bulbar Odontoma (Forget).

a certain amount of force being required. It measured one and a half by one and a quarter inches, and on section showed "a cap of enamel, varying in thickness, arranged over a portion of the irregular surface of the mass. Beneath this, well-formed dentine, forming a considerable thickness, was met with; and still deeper in the substance of the mass true bone, containing lacunæ, canaliculi, and Haversian canals, was seen to be intermingled in a confused manner with portions of dentine, so as to form the substance called by histologists 'osteo-dentine.'" These tumors have been hitherto met with in the lower jaw only.

FIG. 180.

Tomes's Case, from *Transactions of the Odontological Society*, vol. iii.

Radicular odontoma is extremely rare: it is met with in the lower jaw, and is an hypertrophy of a fang. Salter's case[2] is classical: he describes the growth as composed of an outer layer of cementum, within which is a layer of dentine, within which, again, is calcified tooth-pulp. This case is "composed of a confused mass of bone-structure and dentine-structure arranged around and separating an elaborate vascular network of the same character

[1] *Edinburgh Med. Journ.*, Jan., 1873.

[2] *Guy's Hosp. Reports*, 1869.

as that of the dentinal pulp." Forget as well as Tomes has described similar growths.

Treatment consists in removal of the growth, together with the tooth immediately involved. This should be done through the mouth, without incision, so as to leave no scar; excision of a portion of the jaw is needless; by means of chisel and forceps the bone can be pressed away from the tumor sufficiently to permit of its enucleation; the cavity remaining after removal will be allowed to heal by granulation.

Fracture of the Upper Jaw.

Fracture of the upper jaw occurs more rarely than fracture of the lower maxilla. The line of fracture is usually very erratic. Direct violence generally produces the injury, although a blow upon the malar prominence may induce crushing in of the antrum. While this bone is rarely broken, cases are on record where, from great violence, the lines of fracture seem to run in all directions, separating the bone into many pieces and apparently severing its connections with adjacent bones. Such a case was shown to me by my colleague, Prof. Christopher Johnston, some years since. The patient, Capt. F——, was struck full in the face by the walking-beam of the steamboat under his command: the face seemed literally to consist of a bag of bones moving freely with inspiration and expiration, so extensive was the comminution. The body of the bone is infrequently broken; fracture of the processes is, however, more frequent, the nasal processes sharing the fate of crushing violence upon the nasal bones; or the alveolar border may be separated from the body. Separation of one jaw from the other in the median line has been seen. The upper jaw, enclosing the antrum and bounding so many cavities, presents two marked phenomena with fractures—1st, hemorrhage; 2d, the fractures are often compound.

The bony plates of which the jaw is built are covered on each surface by thick vascular membrane—muco-periosteum—which is often torn, giving rise to bleeding, which may be very great at first, but which also may be expected to cease under hot-water irrigation. While the tearing of the muco-periosteum likewise renders the fractures compound, such lesions are not accompanied by the discomforts and dangers of compound fractures of long bones, owing doubtless to the fact that the bony plates already mentioned are nourished by the periosteum upon either surface; so that if on one side the muco-periosteum is injured, the nutrition of the bone is not impaired, it being supplied from the other. It is interesting to note as confirmatory of this view that after fracture the alveolar border is more often subject to necrosis than any other part of the bone; and this border, being the thickest part of the bone, is nourished, of course, with difficulty from one side, the periosteum being torn from the other.

Fractures very rarely extend through the face and involve the skull, unless from gunshot violence, the upper jaw acting in the capacity of "buffer" for the protection of the brain-case. Fractures extending to and involving the alveolar border will in almost all cases displace or loosen teeth; such teeth should not be removed.

The prognosis in the ordinary run of cases is good as regards restoration of appearance and function, and even when the condition of affairs can be indicated only by the term "general crush," still, the prognosis is favorable. Necrosis, for reasons already stated, is very rare. Two complications are to be looked after in fracture of the body of the jaw: injury to the second division of the fifth nerve, infraorbital, and occlusion of the nasal duct. Both of these accidents are rare, and need appropriate surgical attention: of the two, occlusion of the nasal duct is the more often met with. An increased flow of saliva is generally seen after fracture, and if the buccal mucous membrane is torn, some fetor of breath is to be expected. The mouth, nose, and orbit, all affording access to the upper jaw, there should be no difficulty in reaching a correct diagnosis: loss of function, irregularity of the teeth and dental arch, mobility, displacement, and crepitus are the symptoms mainly to be relied on.

Treatment.—In the majority of cases no splint is required, the infiltration from inflammation and consequent stiffening of the mucoperiosteum being sufficient to retain the edges of the fracture in apposition. In more extensive injuries, with displacement of teeth, the cardinal rule is to remove no pieces of bone or teeth, to replace everything, to retain by interdental splints, to keep the mouth clean, and, as the fragments unite, to place them in their proper relations to one another. No matter how great the lesion or how unpromising the outlook, much good will result from carrying out the above principles. After the bones are firm, then the regulation or replacement of teeth will need attention. Much ingenuity can be shown by the surgeon in the treatment of severe lesions. In the case of Capt. F——, already referred to, Prof. Johnston passed a silver wire under the upper jaw, out through each cheek and united the ends over the top of the head by a rubber band, thus slinging the bones in position: a very excellent result was attained. In a case where I cut across both upper jaws, so as to obtain access to the naso-pharynx for the removal of a tumor growing from the base of the skull, I made use of the wire sling as above with a favorable result (Johnston's method).

Gunshot Injuries of the Upper Jaw.—These need but a passing notice here. They always fall at first into the hands of the general surgeon, and into the hands of the dental surgeon only after, recovery being obtained, it becomes a question how to restore form and function. This subject is discussed elsewhere. It may not be out of place to call attention to the fact that foreign bodies of large size may lodge in the upper jaw (antrum), and evince their presence by a persistent discharge only, no swelling being perceptible.

Fracture of Lower Jaw.

Fracture of the lower jaw is most often seen during the period of active life, say between twenty and forty years; it is rare in childhood and old age. The male sex enjoys the privilege of experiencing this fracture nearly ten times as often as the female. Violence, direct or indirect, induces the fracture, which in the great majority of cases will be

through the body; then, in order of frequency, through the ramus; and lastly, through the processes: this refers of course to complete fracture, not to the tearing off of a piece of alveolus, as sometimes happens during the extraction of a tooth. Complete fracture passes entirely through the bone, separating it into two portions; incomplete fracture means a chipping off of the border of the bone, usually the alveolar border, with perhaps the displacement of certain teeth, but the two condyles being still connected by the continuous arch of bone. Fractures in one or two places, single and double, occur in the proportion of nearly 2 to 1, but fractures in more than two places, multiple, are very rare.

The line of fracture is usually oblique, not only from above downward, but also it is oblique from before backward through the thickness of the bone. The line of breakage is rarely smooth, certain irregularities being present which materially assist in retaining the fragments in apposition. Compound fractures are probably more frequent than simple fractures, and are generally into the mouth—a condition of affairs largely due to the presence of teeth, which become displaced as the line of breakage passes through their sockets. A break not compound at first may become so by suppuration in a tooth-socket. The line of fracture is more nearly vertical in the body of the jaw than in the ramus, and occurs very rarely at the symphysis, usually being just to one side of the middle line. A double fracture existing, one fracture will often be on either side of the symphysis, though exceptionally symmetrical. The central fragment will then be drawn down toward the sternum, carrying with it the tongue, which is attached to the genoid tubercles: if the portion of bone included between the lines of fracture is very mobile, the tongue may fall backward and interfere with respiration.

Fracture of the ramus may often be accompanied by a second break in the body, and if the ramus be broken where it lies between the masseter and internal pterygoid attachments, there will be no displacement. The fractures that I have seen just in front of the masseter muscle were most difficult to retain in position.

Fracture of the neck of the condyle ordinarily results from violence applied to the chin, so well protected is it by the zygoma.

Fracture of the coronoid process is a surgical curiosity which, theoretically, might be produced by the action of the temporal muscle, but which would probably escape a diagnosis: apposition of the fragments, save by wiring, would be impossible with our present knowledge.

Displacement in single fracture of the body depends much upon the violence of the injury and the direction of the line of fracture. Apposition is generally easy; in multiple fracture with displacement downward to a marked extent, it is necessary to wire the central fragment at each end. Reference has been made to fracture in front of the angle: the difficulty appears to result from the action of the masseter, which raises the posterior fragment.

When the line of fracture extends through the neck, the condyle is drawn forward by the external pterygoid muscle.

The prognosis in fracture of the lower jaw is good as regards both function and form, excepting only when the condyle is separated from the rest of the bone: here the impossibility of manipulating or retain-

ing in position the free fragment sufficiently accounts for the unfavorable outlook. Non-union is extremely rare.

SYMPTOMS OF FRACTURE.—These are usually plain: the history of violence, pain, crepitation, loss of function, irregularity of the teeth, undue mobility, displacement, and excessive flow of saliva make a picture not easily mistaken.

Complications are rarely met with, save in gunshot fractures, which often demand the attention of the general surgeon, and may be omitted here. Abscess, followed by superficial necrosis and fistula, is occasionally seen; after separation of the fragment all trouble ceases. A similar result may follow the passage of the line of fracture through the cavity of a permanent tooth; nerve-lesion is very rare.

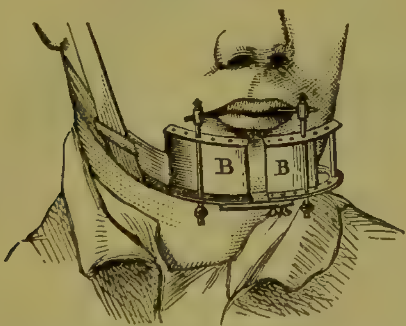
FIG. 181.

FIG. 182.

Bandage and Splint for Fracture of Lower Jaw (Bryant).

TREATMENT.—Few fractures of the lower jaw are not amenable to simple treatment: the four-tailed bandage, with or without a pasteboard cap for the chin, suffices usually Now and then, however, a case presents which calls for most careful attention, owing to recurrent displace-

FIG. 183.

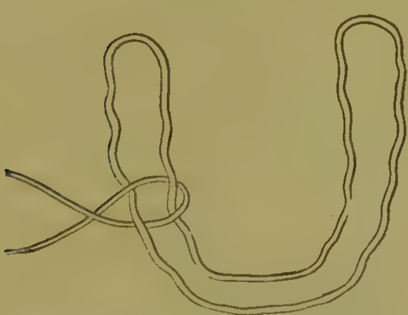


Moon's Interdental Splint, made in two halves, *B*, *B*, with horizontal rods to keep cap Fig. 184 in position (Bryant).

FIG. 184.

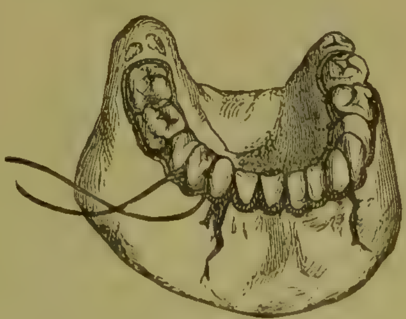
Metal Cap fitted over Fractured Jaw, represented as wired on for a time, after the withdrawal of external splint (Bryant).

FIG. 185.



Hammond's Wire Splint for Fracture of Jaw (Bryant).

FIG. 186.



Hammond's Wire Splint applied to Fractured Jaw (Bryant).

ment from muscular action or inability on the part of the surgeon to

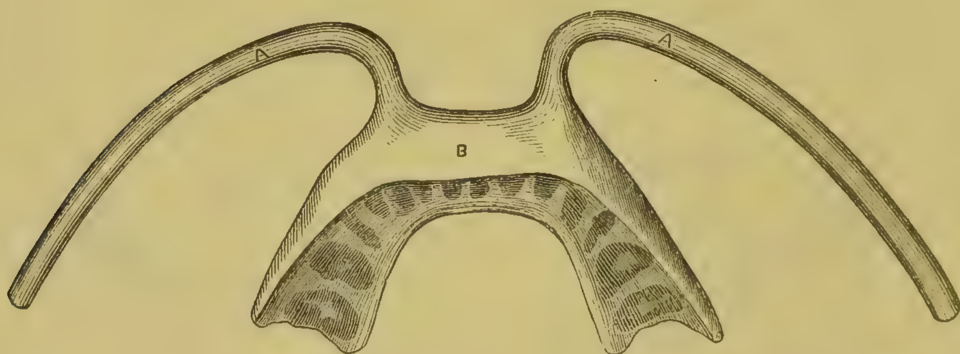
place the fragments in proper apposition. Interlocked or impacted fragments should be separated and placed in proper apposition, and retention secured by wiring the teeth, by an interdental splint, or by one of the forms of splints for which we are indebted to dental surgeons, as Kingsley's, Hammond's, Bean's, Moon's.

FIG. 187.

Kingsley's Splint applied (Stimson).

The crush of the jaw may be so extensive as to preclude the use of any splint, especially if few or no teeth are present: here it will be necessary to place the pieces and teeth as repair goes on, and the thickening of the gum during the second week after injury will frequently retain fragments in good apposition. The use of an artificial denture to replace lost teeth is inexpedient until the jaw is firm and callus disappearing.

FIG. 188.



Kingsley's Splint (Stimson).

DISLOCATION OF LOWER JAW.—Dislocation of the lower jaw occurs as a unilateral or bilateral accident, the latter being much the more frequent. Owing to the anatomy of the temporo-maxillary joint, displacement of the condyle cannot occur backward or upward, and outward only after fracture of the bone; hence much the most common dislocation is forward. Opening the mouth causes the lower-jaw condyles to slide forward upon the articular eminences, carrying also the interarticular fibro-cartilages, and a forward movement in excess carries the condyles beyond the summit of the eminence into the fossa beyond. Spasm of the external pterygoid doubtless has much to do with the production of the accident. Relaxation of structures about the joint is a strong predisposing cause; hence the accident is met with in middle life most commonly, and in the female more often than the male. After the occurrence of the displacement the mouth remains open, the jaw fixed, speech and deglutition are much impaired, the temporal

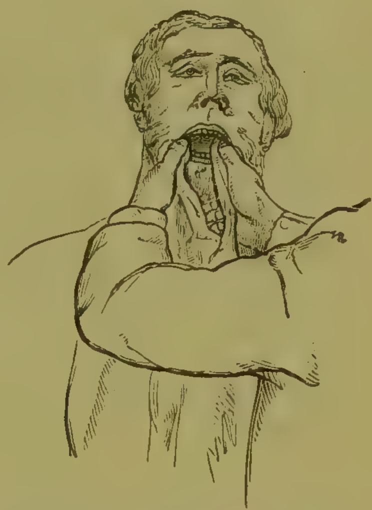
muscle is tense above the zygoma, and the coronoid process perhaps felt from within the mouth; a depression in front of the ears is noticed, profuse salivation takes place, and great pain may be complained of. Unilateral displacement, one condyle forward, produces the usual symptoms, but to a less extent than in bilateral dislocation; in addition also the symphysis is carried to the non-dislocated side.

Vomiting, yawning, shouting, or whatever opens the mouth widely, may induce dislocation; external violence, as a blow or tooth-extraction, is less often the exciting cause. Dislocation having occurred once, may again happen, and the joint structures may be so relaxed that displacement takes place with the smallest provocation. Such a case fell under my observation a few years since, the subject being a feeble woman; during one day I reduced three times bilateral displacement of her jaw.

Fig. 189.

Dislocation of Lower Jaw (Bryant).

Fig. 190.



Reduction of Dislocation of Lower Jaw (Bryant).

Reduction is simple, and effected by pressing the lower jaw downward so that the condyles can ride backward over the articular eminence: as soon as this occurs the jaws are closed strongly, and the fingers of the operator are liable to be bitten. Appropriate manipulation is as follows: The patient sits upon a low seat facing the surgeon, the head resting against the wall to prevent a movement of retreat from the operator; the thumbs of the surgeon, wrapped with a bandage to avoid bruising, are passed into the mouth of the patient, resting upon the posterior molar teeth. Pressure is made downward and backward; at the same time the fingers rest lightly upon the skin covering the angles of the jaw: in a few moments the condyles return to their proper position and the dislocation is reduced.

If the dislocation is of long duration, it may be necessary to reduce one condyle at a time.

Necrosis of the Jaws.

Necrosis is met with in connection with either jaw, but with the lower more frequently. The anatomy of the maxillæ sufficiently explains this difference. The blood-supply of the lower jaw, and nerve-supply also, are obtained through the ends of the bone, and there is little inosculation in the middle line of the chin between the vessels entering the two post-dental canals: any obstruction to circulation is repaired with difficulty, and nutrition suffers; the lower jaw may be considered as a long bone. The upper jaw receives both blood-

and nerve-supply from different directions, and is largely composed of thin plates—antral walls, palate processes—supplied with periosteum on each side, so if obstruction to flow of blood occurs in one direction, it can be compensated for by increased flow from another. In either jaw the outer surface of the bone is more often first affected; periostitis, save in exceptional cases, ushers in the disease; the necrotic process may be limited to bone in relation with the inflamed periosteum, or, extending deeper, may involve the alveolar border, and perhaps the palate if the upper jaw is the one affected. A central sequestrum is met with in the lower jaw, not in the upper. A necrosis limited in extent and confined to the hard palate is strongly suggestive of syphilis. Teeth in a jaw the subject of necrosis loosen, become dark, and are ultimately removed or fall out: very exceptionally a certain number remain firm. Milk teeth are always loosened by necrosis, and the germs of permanent teeth are destroyed: inasmuch, however, as the necrotic process follows no regular line, it is not always possible to say what permanent teeth may have escaped destruction. Thus, it occasionally happens that after the dead bone is cast off, a tooth may appear in the cicatricial tissue which replaces it, or where a permanent tooth is lost another tooth may be erupted, apparently in its place. Such observations have given rise to the idea that a third dentition may occur, which is erroneous; for the true explanation is that the necrotic process has passed around the tooth-germ, destroying adjacent bone, but not the germ itself.

Traumatism, scurvy, syphilis, certain eruptive fevers, inflammation of periosteum and peridental membrane, mercurialization, and the action of phosphorus, are the most frequent exciting causes of necrosis. The predisposing cause is anything which tends to diminish the resistance of the patient's tissues. In the days when it was the habit to treat malarial and continued fevers with large doses of calomel and blue mass, necrosed jaws were far more common than at present. Salter has directed attention to a form of necrosis seen after the eruptive fevers—measles, variola, scarlatina, etc. The patient is under ten years of age; the alveolar border of the bone is affected, and the disease is generally symmetrical; the soft parts adjacent to the bone usually escape destruction; hence cicatricial bands are not often found. In cases where there is much cicatricial contraction of soft tissue associated with necrosis of the jaw following one of the eruptive fevers, I have always obtained a history of mercurialization. Cancrum oris involving the jaws is always productive of strong cicatricial adhesions between the cheek

FIG. 191.

Destruction of Cheek, the result of cancrum oris.

and bones. Necrosis among looking-glass workers was seen by physicians before the present methods of making mirrors were in use.

Another form of jaw-necrosis, now, fortunately, but rarely seen, is that due to phosphorus fumes: it was formerly often met with in the persons of those employed in the manufacture of lucifer matches. This form of disease attacks those in whom a recently-extracted or a carious tooth gives opportunity for the entrance of the poison, the bone in the immediate neighborhood being first attacked, the disease then gradually extending. Great swelling of soft tissue, with separation of the periosteum, marks the progress of the trouble, and great flow of pus occurs, much of which passes down the patient's throat, impairing digestion. Phosphor necrosis is more frequent in the lower than upper jaw: cases have occurred in which the entire bone, including processes, has died and been removed.

Repair after necrosis is more perfect in the lower than in the upper jaw. It is an open question as to how much bone and how much fibrous tissue will be formed by the periosteum after lower-jaw necrosis; but if the whole bone dies the surgeon may confidently expect a good working substitute to be reproduced—not of course with teeth, but entirely sufficient for the support of an artificial denture. The upper maxilla is

Fig. 192.

Sequestrum following Necrosis of Lower Jaw.

never renewed to nearly the same extent, and the palate processes are not reproduced at all; hence palate perforation needs a plastic operation or an obturator, and the surgeon errs in expecting the gap to close by cicatrization. A gradual thinning has been noted in a reproduced lower jaw.

Necrosis has been known to extend from the jaw to adjacent bones, and so involve the brain with fatal result. Symptoms are usually sufficiently plain: pain in one or more teeth, at first intermittent, subsequently becoming constant, perhaps preceded by a periostitis, gradual loosening of the teeth, swelling of the gums, exudation of pus from the sockets of the teeth, detachment of the gum from the bone, with flow of

pus from the gutter thus formed, swelling of adjacent soft tissues, more marked in phosphor-necrosis than any in other variety, and the formation of external fistulæ,—all contribute to make up a picture admitting of no difficulty in diagnosis.

The treatment of necrosis is to be considered under three heads: 1st, prophylaxis; 2d, threatened necrosis; 3d, necrosis present.

The first relates to preventive medicine, and need scarcely be discussed here. In the second class extraction of blood and relief of tension by free incisions into the swollen area, with removal of all sources of local irritation, combined with change of air and diet, also suitable tonics, may suffice to arrest the threatened danger. When, however, the third stage is reached, it is probably better to wait for the dead bone to separate from the living as well as from the soft parts, before attempting removal. In this manner all bone possible is saved, as well as teeth and teeth-germs; new bone is formed by the separated periosteum (lower jaw); and the contour of the face is better preserved. *Per contra*, the flow of pus may impair digestion, and if the suppurating surface is large septic infection, acute or chronic, may supervene. The surgeon then should support the patient's strength by appropriate means, and keep the mouth clean by washes until the dead bone can be removed without detriment to the living. The sequestrum is to be removed through the mouth, to effect which it is to be extracted piecemeal if necessary; furthermore, the bone only must come away, the cradle of periosteum being left to form new bone. By gradually separating the periosteum the entire lower jaw has been removed and a new one, more or less perfect, reproduced.

Solid Benign Tumors of the Upper Jaw.

Solid non-malignant tumors of the upper jaw are either fibrous, cartilaginous, or bony.

Fibrous Tumors.—Histologically, these growths are similar to fibrous growths found elsewhere in the body. They are firm, elastic, perhaps lobulated—on section white, showing interlacing bundles of fibres. The most frequent situations are in the antrum or from the periosteum of the alveolar border. Broca believes many fibromata originate from a tooth-germ, and that they are then encysted and may be enucleated. Irritation probably is a frequent cause, a blow, a carious tooth, etc., being sufficient, although in many cases such a history is wanting. Their growth is slow, and, according to situation, gives rise to varying deformity; when in the antrum, after a certain size is attained, expansion of the upper jaw takes place, with absorption of bone; the tumor may project toward the nose, mouth, pharynx, or, extending downward, overlap the teeth; when, however, growth commences in or upon the alveolus, extension outward occurs, and deformity is at an early stage of the tumor apparent. Generally speaking, extension of the growth takes place in the direction of least resistance, but pedunculation does not occur, as is so common with sarcomata about the cavities of the face. Projection into the naris of a portion of the tumor may give rise to epistaxis; adjacent organs and tissues, although displaced by pressure,

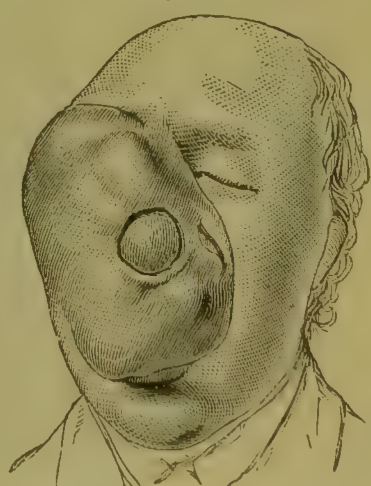
are not incorporated with the tumor, and remain healthy, resuming, when permitted, their natural positions as well as their functions. Especially is this the fact with the eye, which may be greatly displaced and yet vision remain perfect. Calcareous degeneration of portions of the growth is occasionally observed. The great size some-

FIG. 193.

Fibroma of Upper Jaw (Liston).

times attained is well seen in the noted case of Mrs. Fraser, successfully operated upon by Liston. A fibroma thoroughly removed does not return, but in order that removal may be thorough the bone from which the tumor springs must also be taken away. Exception in this regard may be made to the odontomes embryo-plastiques of Broca, already referred to; which, by the way, are only seen in early youth.

FIG. 194.



Enchondroma of Upper Jaw (Bryant).

Enchondroma of the upper jaw is very rarely encountered, the outer surface of the bone being the chosen seat of the tumor, which originates in youth generally. Growth is slow, neighboring organs are pressed aside, pain is absent, and deformity may be very great: ossification in the tumor is met with, but the presence of a certain amount of fibrous tissue is to be expected. Compared with fibroma, enchondroma is harder, of slower growth, and less irregular upon the surface. The only treatment worthy of thought is extirpation of the growth, together with the subjacent bone.

Osteoma is encountered less frequently than either of the varieties

already mentioned, and is met with as an outgrowth from the anterior surface of the jaw or from the antral wall: it may be composed of compact or cancellated tissue; exceptionally, a bony tumor of the palate is seen. I had occasion to operate some years ago for the removal of a palatal osteoma which caused inconvenience from interfering with the movements of the tongue: it grew from the buccal surface, and resembled an imbedded tooth; it was composed of compact tissue. The very slow growth, extreme hardness, and great distortion of adjacent tissues and organs render a diagnosis easy.

A remarkable example of pedunculated bony tumor is preserved in the Musée Dupuytren (Figs. 195 and 196); this growth by pressure has

FIG. 195.

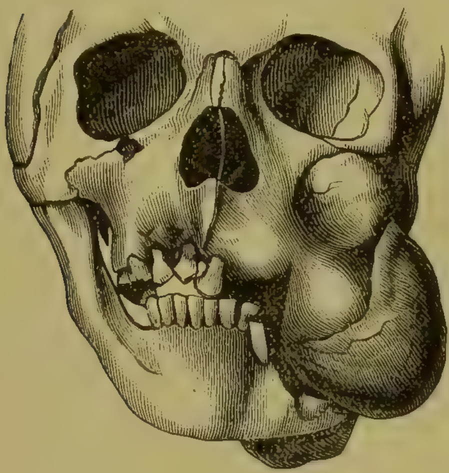
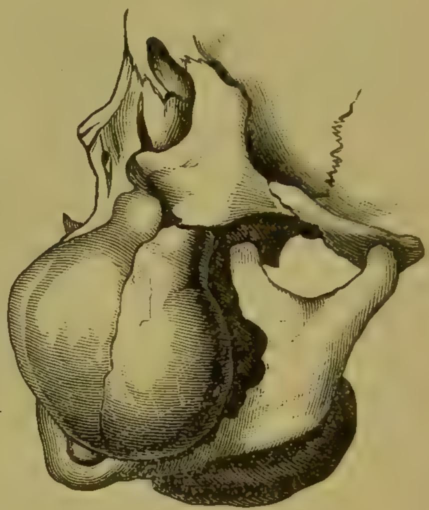


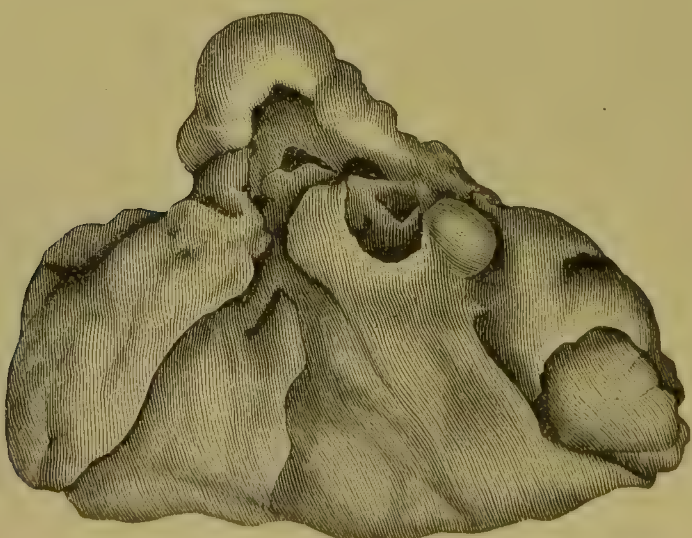
FIG. 196.



Osteoma of Upper Jaw (from *Musée Dupuytren*).

gradually induced great deformity of the corresponding half of the lower jaw. Spontaneous separation of such a tumor has occurred from

FIG. 197.



Osteoma of Upper Jaw (Heath, from *Path. Trans.*).

absorption of the neck, but such a result is not to be expected: in like manner, an osteoma projecting into the antrum may become, look, and

act as a foreign body. Fergusson removed an osteoma of dense structure weighing ten and a half ounces, which had invaded both antrum and orbit.

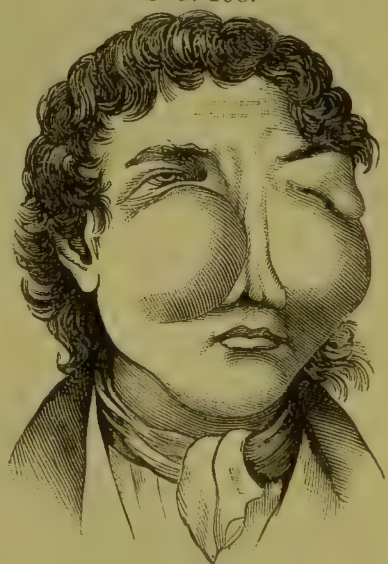
The operative measures incident to the removal of upper-jaw growths will be referred to later.

Non-malignant Tumors of the Lower Jaw.

These should properly be considered with the previous section, but there are certain points of difference worthy of note. Thus, while the three varieties of tumor, fibroma, enchondroma, osteoma, are met with both upon the surface and within the inferior maxilla, periosteal and endosteal, yet as the bone contains no large cavity, such as the antrum, and is not in relation with large chambers, pharynx, orbit, nares, any change of shape is at once noticed. In addition to which, the lower jaw being movable, interference with function is early recognized. Endosteal fibroma is met with most often between the symphysis and angle: it may occupy the dental canal and involve the nerve; increase is greatest downward and outward. Enchondroma occurs, like fibroma, in a periosteal and endosteal form, and, like fibroma, may be occasionally enucleated, thus preserving the line of the lower jaw, upon the retention of which depends so much expression. Ivory exostosis is occasionally encountered, and generally near the angle.

There has been described by Bickersteth, Howship, and others a deformity of the jaws, both upper and lower, but more often the former, characterized by great deposit of new bone and filling up of all spaces in the old bone. The disease appears to depend upon a chronic periostitis, but, so far, has not been made out to depend upon syphilis, struma, or other recognized cause of bone-sclerosis. The patient in Howship's case lived more than sixty years, the upper jaws being changed into large ivory-like masses. Bickersteth's case showed an hypertrophy of all the head bones except the occipital. Heath states that there is in the museum of the College of Surgeons, London, the skull of a Peruvian showing the same form of disease in the bones of the face, as well as in certain bones of the skull.

Fig. 198.



Hyperostosis, Howship's Case.

Treatment by medication has not hitherto been of use: where the hyperostosis was limited, excision has been practised; but where diffused, palliatives have been resorted to, and without benefit.

Disease of the Temporo-Maxillary Articulation.

This is comparatively infrequent: if present, it does not differ in course or result from that which is met with in other joints when the

subject of disease. Rheumatoid arthritis, with the well-known modification of the bone-surfaces composing the joint, has been figured by several writers. On two occasions I have recognized syphilitic disease of the joint: in both instances the symptoms were similar—namely, discomfort during motion of the jaw, becoming more pronounced, until after a few days acute, agonizing pain supervened, rendering the patient unwilling to speak or chew; pain on pressure over the joint; pain from pressure on the chin directed so as to force the condyle into its socket; marked exacerbation of pain at night; prompt relief from antisyphilitic treatment. Both patients were comparatively young, and in each both joints were involved, though not equally.

After scarlatina, destructive inflammation of this joint may take place, which is rarely if ever bilateral. In the two instances that have fallen under my observation I formed the opinion that a suppurative arthritis took place, which discharged through the external auditory canal: the history obtained from the patients' families did not support the theory that the inflammation was propagated from the auditory canal or middle ear. (This subject will be referred to under the head of Ankylosis.)

Fig. 199.

Hypertrophy of Neck and Condyle (Heath, from *Path. Soc. Trans.*).

Chronic rheumatic arthritis may give rise to an hypertrophy of the condyle and neck of the lower jaw on one side, which, if it progress at all, induces marked deformity. The movements of the jaw become restricted, the teeth no longer are properly opposed, and the chin is carried beyond the middle line of the face. No treatment save excision of the condyle and neck is to be thought of for a moment.

The treatment of disease affecting this joint is the same as for other joints of the body.

Malignant Tumors of the Upper Jaw.

Epithelioma of the antrum and of the gum covering the upper jaw has been already described, and may be omitted from the present section.

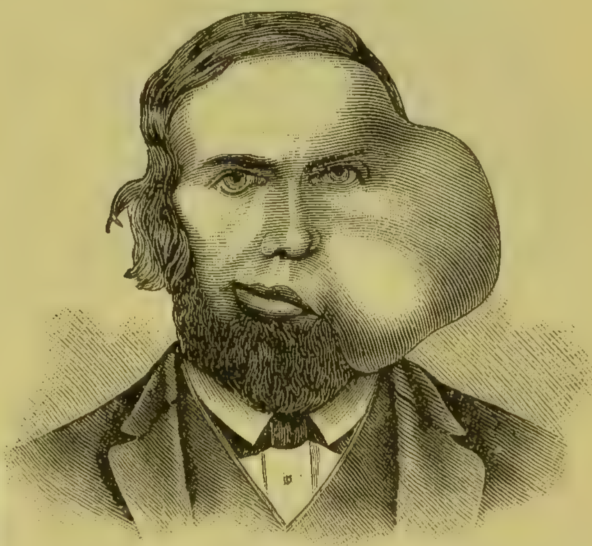
Malignant growths of the upper jaw very generally belong to the class of sarcomata, and are thus often seen in the earlier years of life. Spindle-, round-, and myeloid-celled tumors have been seen, but the latter most frequently; and fortunately so, for the characteristics which are known as malignant are less marked in myeloid than in other sarcomata. Small-celled sarcoma is the most rapidly fatal tumor of the upper jaw that I have seen. Carcinoma of the upper jaw, save in the form of epithelioma, I have never seen. Encephaloid is mentioned by authors

as being the carcinoma most frequently met with. A malignant tumor may grow either from the alveolus or the body of the bone, from the surface or centrally. If from the periosteum, a shell of bone may partially enclose it. At first increase is slow: a number of months may pass, during which the bone is being slowly expanded, or perhaps only the cavities adjacent to the maxilla, nose, spheno-maxillary fossa are being encroached upon. Finally, the restraining walls of bone are absorbed from pressure, or are incorporated with adjacent structures in the tumor, and at once growth becomes extremely rapid, giving rise to most loathsome appearances. A tendency of outgrowths to become pedunculated on mucous membrane is apparent, while upon a skin surface, when protrusion occurs, sloughing is frequent, together with hemorrhage. This tendency to protrusion is especially to be remembered in the nose, where a polyp may be but the small part of a large growth in the antrum or post-nasal space. In the

FIG. 200.

Sarcoma of Upper Jaw (from patient in University Hospital).

FIG. 201.



Sarcoma involving both Upper and Lower Jaw (Heath).

same way, the appearance of a tumor in the orbit or after perforating the palate is to be carefully examined. Pain in the early stage is exceptional; later, it may become distressing; usually, it is referred to certain teeth. When the trunk of a nerve is involved, pain is much more severe; reflected pain is not uncommon, but where two branches of the fifth nerve are the seat of much pain, suspicion of an intracranial lesion is aroused. If the growth is sarcoma, glandular implication is generally not present, the reverse occurring with carcinoma. I have in several instances been able to trace sarcoma of the upper jaw to injury, and incline to the belief that traumatism is a cause more often than is generally believed.

The diagnostic points especially to be relied upon between benign and malignant growths are—1st, causation; 2d, rapidity of growth; 3d, incorporation of adjacent parts; 4th, behavior upon a skin or mucous surface; 5th, secondary growths elsewhere, glandular or not.

Before definitely deciding upon an operation for the removal of an upper-jaw tumor, it has been my custom for some years to cut into the growth unless the diagnosis were beyond peradventure. The incision in no way militates against the success of further operative measures, and a number of cases are on record in which severe operations have been avoided by the adoption of the above precautionary exploration.

The upper jaw is in relation with so many cavities that scarcely any part of the body is more accessible for diagnostic purposes; the mouth, nose, and orbit afford channels for exploration in three directions, while a finger passed up behind the soft palate can reach the base of the skull and the posterior aspect of the bone. The remaining bone-surface can be appreciated through the cheek.

Fig. 202.

Malignant Tumor of both Jaws (from patient in Presbyterian Eye and Ear Hospital).

The treatment of malignant tumors means free excision of the growth and all adjacent structures, the methods for which are referred to later. The question will always arise, however, Is it worth while to operate at all? Each case must be judged upon its own merits, but where death is otherwise inevitable a chance of relief and cure should always be offered to the patient.

Malignant tumors of the lower jaw, as with non-malignant, will be found to differ from upper-jaw growths in certain peculiarities only. Epithelioma of the lower lip is very common, and while direct extension of the disease to the maxilla is not often seen, for excision is usually done early, yet glandular infection is often seen, and the body of the jaw is implicated in the secondary growth. Another peculiarity is that the lower line of the jaw is subcutaneous, and the whole bone can be grasped by the fingers and carefully examined, so that, as there is no air-chamber in the bone that the tumor may grow in, any departure from the normal shape ought to be at once detected. It is a fact of interest that epithelioma of the lip is not seen in the negro.

Excisions of the Jaws.

Operations within the mouth present to the surgeon the problem how to prevent blood necessarily drawn from flowing into the trachea and so asphyxiating the patient. Prior to the discovery of anæsthesia, operations upon the mouth were undertaken with the patient seated, the head leaning somewhat forward that the blood might escape through the lips; but as the erect position is incompatible with safe ether or chloroform narcosis, an essential to operations at present, a provisional trachcotomy, combined with some sort of laryngeal occlusion, is generally

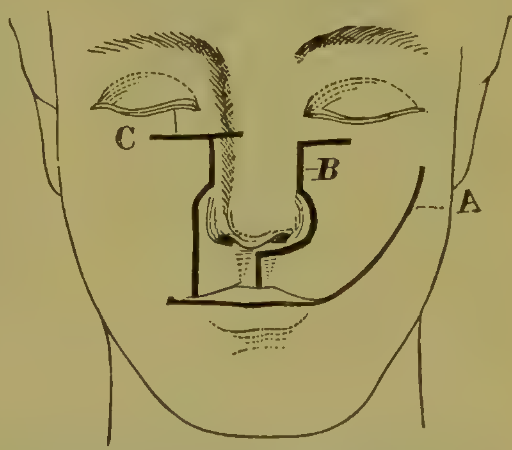
adopted. This permits the patient to keep the supine position during anæsthesia without fear of blood entering the air-passages. But tracheotomy is always a complication to be avoided if possible; and so in a number of cases I have performed bloody operations of one kind or another as follows: The patient receives a full dose of morphia hypodermically, and half an hour later anæsthesia is induced. The patient is then turned abdomen downward, the thorax projecting beyond the edge of the table; an assistant at each shoulder supports the upper part of the trunk, and one standing behind the shoulder supports the head, directing the face toward a window. Thus blood flows downward and forward from between the lips into a proper vessel, not back into the trachea. I have removed the upper jaw from a patient in this position, yet no interruption from hemorrhage occurred. The surgeon, unless the table be of unusual height, is obliged to operate either kneeling or seated.

Hemorrhage in mouth-operations is usually free, and hot water is an excellent hæmostatic; the position above mentioned permits not only the use of sponges wrung out of hot water, but allows, without fear of asphyxia, a current of hot water, by means of a Davidson syringe, to be directed into the mouth and brought to bear upon the bleeding surface.

So elastic are the mouth and lips that excision of the greater part of either jaw can be done without dividing the skin; the special instruments required are strong bone-cutting forceps, having blades set on the handles at different angles. Where a little more room is needed, free dissection of the cheeks from the maxillæ may be resorted to: should still more room be desired, a division of either lip in the middle line may be made; in the upper lip the upper end of the cut may be carried into a nostril with advantage.

Excision of the upper jaw is effected as follows: An incision is carried through the middle line of the upper lip, around the ala of the nose, and then upward nearly to the inner canthus: if the growth to be removed is large, a cross cut below the eye may be made or the incision may be carried through the lower lid into the palpebral fissure. These incisions reach the bone. The large flap bounded by these lines is to be reflected from the subjacent jaw and held out of the way. The attachments of the jaw to its fellow of the opposite side in the middle line, and to the frontal and malar bones, are then to be divided, either by a saw or by cutting-pliers, or by both. It is my habit to use extremely strong cutting-pliers for this purpose: with one blade in the nose and one in the mouth I am enabled to divide the hard palate and alveolus at one pinch; in the same way the other connections mentioned are severed. If the palate bone is to be left, it is to be separated from the hard palate by a fine saw; if the palate bone is to be taken away

FIG. 203.



Excision of Superior Maxilla: *A*, external incision; *B*, Nélaton's incision; *C*, Boeckel's incision (Stimson).

with the jaw, then the soft palate must be separated from the palate bone. Either curved scissors or a probe-pointed bistoury or Paquelin's cautery can be used for this purpose. The jaw can then be grasped with strong forceps and twisted from its position. I have never seen hemorrhage of sufficient moment to cause anxiety follow the operation: pressure with hot sponges or a stream of hot water directed on the raw surface will arrest oozing. The large cavity is to be filled with iodoform gauze, and the after-treatment conducted on general surgical principles. Granulation is rapid, and deformity after healing is comparatively slight. In case it becomes necessary to remove the malar prominence, the deformity will be much more marked.

Excision of the Lower Jaw.—A great part of the lower jaw can be exposed and removed through the buccal commissure, and where greater space is needed it may be obtained by dividing the lip in the middle line.

Excision of the whole or half of the lower jaw is effected through a skin incision carried from below the lobe of the ear downward behind the ramus to the angle, and then along the under surface of the bone to the middle line of the face. The incision may then be carried through the middle line of the lip if expedient, but this is very exceptionally required. If one-half the bone is to be taken away, it is then to be sawn at the symphysis, and the condemned portion strongly depressed: the soft parts are to be separated from below upward, the mucous membrane being divided last, the operator keeping close to the bone and thus avoiding difficulties. The facial artery is necessarily cut. As dissection progresses the bone is drawn more and more downward and outward; the inferior dental nerve is to be cut transversely a short distance above its entrance into the inferior dental foramen. By keeping close to the internal surface of the ramus the lingual nerve is avoided. The main structure to be avoided is the internal maxillary artery, which passes in very close proximity to the inner side of the neck of the condyle. The most certain way to avoid wounding this vessel is not to attempt to dissect the soft structures from the condyle and neck, but, having separated other attachments, to forcibly twist the bone from its socket. The attachment of the temporal tendon to the coronoid process may be divided with scissors, or, what is still more easy, the tip of the process cut off with bone-pliers. There is another danger to be guarded against if the bone removed passes beyond the middle line of the jaw—namely, interference with respiration in consequence of the tongue falling back over the glottis. This accident is brought about by separating from

Fig. 204.

External Wound for Excision of Inferior Maxilla (Stimson).

their maxillary connections the muscles attached to the genoid tubercles. To prevent this untoward occurrence, a loop of string must be passed through the tongue and tied so as to avoid slipping. This loop must be sufficiently long to be held by an assistant, who should stand out of the operator's way. After the operation is finished the loop may be shortened and fastened by an adhesive strip to the patient's cheek. Iodoform gauze should be used to fill the cavity remaining after removal of the bone. The line of incision indicated has the advantage of being almost entirely out of sight, and so of showing little scar.

Operations within the mouth are liable to be followed by septic pneumonia, resulting, it is believed, from inhalation of the products of unhealthy suppuration, or perhaps from septic fluid trickling into the finer air-passages. Mouth-washes, etc. have failed to prevent this accident; the use of iodoform gauze as a dressing for extensive wounds of the mouth has, however, been followed by most excellent results, and is without doubt at present the most cleanly and serviceable dressing known. Its use has been followed by a greatly diminished mortality.

Ankylosis of the Jaw.

Inability to completely separate the jaws results from causes which can be grouped under four heads: 1st, tumors; 2d, spastic or reflex; 3d, disease of the temporo-maxillary articulation; 4th, adhesions and cicatrices.

Tumors.—Tumors of the parotid, pharynx, or soft palate occasionally, by their size, prevent free motion of the lower jaw; they are apt to be malignant. Mumps is probably the cause in this group most often seen; with the disappearance of the tumor by operation or otherwise the stiffness of the jaws disappears. Quinsy and other acute inflammations need mention only, so well is their action understood.

Reflex spasm of the muscles of mastication is often excited by the eruption of a wisdom tooth, which will very probably be found somewhat misplaced: extraction of the offending organ or of the adjacent tooth, so as to give room, will promptly terminate the affection. In order to separate the jaws sufficiently to extract the tooth, ether may be required, and as vomiting with a closed mouth is apt to force food into the larynx, the stomach must be quite empty before inducing anæsthesia.

Diseases of the Temporo-maxillary Articulation.—The temporo-maxillary articulation is subject to maladies, as are the other joints of the body, and, like them, may remain with impaired motion after subsidence of acute disease. Rheumatic arthritis, chronic in character, will induce bony deposits which may interfere with freedom of motion without great change in the joint surfaces; but inflammation following scarlet fever has given rise to the most intractable cases in my experience. When after scarlet fever abscess forms and necrosed bone is cast off, the case would rightly be considered under the head of Adhesions and Cicatrices.

Adhesions and Cicatrices.—These constitute the most serious group of the four classes, and the most rebellious to treatment. Adhesions

and cicatrices result from wounds made by firearms; mercurial stomatitis, fortunately now rarely seen; sloughing of the cheek from cancrum

FIG. 205.

Slough of Cheek, opening mouth, from caustic used by cancer-curer.

FIG. 206.

Perforation of Cheek from Mercurial Stomatitis, with cicatricial adhesion.

oris; destruction of the cheek by caustics under the direction of so-called cancer-doctors, etc.

No rule or description applies to the number, extent, or thickness of the cicatricial bands in these cases. Perforations of the cheek, the borders of the hole being adherent to the jaws; thick cicatrices extending from one jaw to the other, plates of bone even extending between and firmly uniting the two jaws,—have all been seen. In addition to which, acute suppurative inflammation of the temporo-maxillary joint, with resulting destruction, may be present to complicate the other conditions.

GENERAL TREATMENT.—The general treatment only can be referred to here, for as cases of maxillary ankylosis are among the most difficult of surgical accidents to treat, every case must be considered on its own merits, and the proper remedy found. Gradual stretching of cicatricial bands, combined with multiple small incisions into resisting structures, gives excellent results. The incisions are to be made with a fine knife-tenotome, and Goodwillie's gag effectually separates the jaws. Pressure should not be made directly upon the teeth, for they are quickly forced out of position, but plates are to be adjusted to the crowns of the teeth, so as to distribute pressure. The use of wedges forced between the unprotected teeth is a return to mediæval barbarism. Very thin plates over a few teeth can be first used, and as more space is gained thicker plates can be made, resting upon and distributing pressure over more teeth. When there is great impairment at the temporo-maxillary articulation, excision of the condyle is necessary. The operation is easily and rapidly effected through an incision just below the zygoma, the bone being divided with a chisel. The wound heals quickly under antiseptic dressings. Attempting to permanently improve an ankylosis

resulting from destruction of this joint, without excision, is but a waste of time. An ankylosed lower jaw is apt to grow more slowly and develop less than the corresponding upper jaw, to which it should be accurately opposed; hence the chin does not project as it should, and noticeable deformity is present. Faradization and massage are beneficial in restoring power and bulk to muscles atrophied from non-use consequent upon ankylosis. It is to be remembered that cicatrices so dense as to bind together the jaws firmly are usually accompanied by deformity of the face, which will also require repair.

General Outline of Principles Governing the Performance of Plastic Operations about the Mouth.

Plastic surgery of the face is divided into—

1st. Measures for the restoration of parts congenitally at fault, either from excess or deficiency.

2d. Measures for the restoration of parts deficient in consequence of accident or disease.

3d. Measures for the correction of deformity produced by cicatricial contraction, this last class being usually associated with the preceding—namely, an acquired deficiency of parts.

The first class of cases, in which parts are congenitally wanting, differs greatly from the two following.

1st. The deficiency results during intra-uterine life, usually from failure of lateral halves to unite, and the deformity is apt to be near the middle line of the body.

2d. The edges and neighborhood of the deformity are usually well nourished, normal tissue bounding the cleft.

3d. During early age the tissues are succulent and vigorous with life, thus lending themselves to new positions.

4th. The same deformity is seen again and again, marked hereditary predisposition being apparent sometimes, as in hare-lip and cleft palate, thus giving ample opportunity for study, and allowing operator after operator to perfect old or devise new measures for relief, perfection so near as possible being gradually attained.

Far different, however, is it with the other classes. Here the deficiency occurs at any time and anywhere; the edges and vicinity of the affected part are made up of cicatricial tissue, and therefore are not well nourished, do not stretch easily, and energetically refuse either to be transplanted or to afford nourishment to a superimposed flap.

With the exception of cancrum oris, which occurs early in life, it is likely that no age is especially prone to accidental face deformity. Still more is the comparison disastrous for acquired deformity when we reflect that, practically, never are similar lesions seen—the same type, possibly, but so very dissimilar in detail that each case is to be studied by itself—and individual peculiarity must govern every operative measure, just as dwellings are built of brick and mortar, but into how many shapes are they fashioned!

It would be well to recall to mind how the face is built on an osseous framework of extremely irregular shape, containing cavities formed

mainly by bones so thin that, being supplied as they are with periosteum on both surfaces, one surface may be denuded, yet no necrosis follow, so free is the vascular supply, one periosteum being able to give nourishment to the entire thickness of bone—a physiological fact already alluded to, and one of very great importance and extremely useful to the surgeon. The region overlying the bones is the most mobile of the body, reflecting the ever-active mental processes; the muscles are noticeable, in that so many have attachment by one end to bone and by the other to muscle, principally the orbicularis oris, thus allowing great play of expression to the mouth. The vascular supply is principally from the sides by branches of the external carotid, and the motor nerve, portio dura of the seventh, is from the same direction. Sensation is supplied by the fifth pair, sending branches through the bones on which the soft parts rest. The great mobility already referred to is attained through the medium of connective tissue, a padding extremely lax and very vascular, which renders this region peculiarly suited for plastic operations, for tissue carrying with it vascular channels after transfer does not die, but grows well in its new situation, having nourishment sufficient.

Remedying a given deficiency comprises—

1st. Obtaining a piece of tissue to fill the vacancy, and preparing its bed.

2d. Putting it in position and nourishing it.

3d. Filling the vacancy resulting from transfer.

4th. Ultimate result as regards usefulness and appearance.

To fill a deficiency in skin of course skin must be taken, and the piece to be chosen should, as far as possible, be similar to the lost piece. A transferred flap should be healthy; scar-tissue must be rigidly excluded, and for this reason, that scar lives upon subjacent parts and is not nourished laterally: if, then, it is raised and transferred, it sloughs and no advantage follows.

It is well to call attention to the fact that support must be afforded to transplanted skin, especially about the mouth. A flap should be so cut that its long diameter corresponds with the known direction of the blood-vessels, and with advantage an arterial branch may be included. The shape must depend upon the gap to be filled; and, inasmuch as there is decided shrinkage when the skin is raised from its bed, the flap should be much larger in all directions than the space which it is designed to fill. This, however, is not always possible, and a flap may be transplanted partly to unite at once and partly to unite by granulation. A flap that is to granulate will require usually a pedicle broader than one which is to unite at once, since in the former case the process of granulation is to be supplied by the pedicle alone, while the latter, certainly at the periphery, is aided by the neighboring tissue. Incisions are to be made where possible in natural furrows and under cover—*e. g.* under the chin—that the resulting scar may escape observation. I have derived great advantage from the homely custom of cutting a pattern of the deficiency, placing the pattern on sound tissue, and with ink or iodine marking out my flap. Enough subcutaneous tissue should be raised with the skin to ensure a good vascular supply. Wolf's plan of skin-flap without subcutaneous tissue or pedicle is still on trial, and will doubtless prove of limited application. No muscle

should be included. Bevelling the skin, as suggested by Packard, may be of use. The surface to which the flap is to be transferred must be prepared by freshening the edges and cutting away all cicatricial tissue, unless resting on a cushion of thick connective tissue; and even here, where there is a thick cushion, granulation will occur and not immediate union. Of course, if the flap edge has been bevelled, the edge of skin against which it is to rest must correspond. Scar tissue, if adherent to bone, is to be removed, and a movable edge made beyond. The transplanted skin becomes adherent by granulation, and, in accordance with the opinion already expressed, such a flap is to be fashioned with a broad base.

A certain amount of hemorrhage is always met with during as well as after the separation of the flap—the first incisions are especially bloody—but a most excellent hæmostatic is to be found in hot water, either poured over the wound or applied by pressing cloths previously wrung out in it against the oozing surface. The temperature should be about 120° F., which will not be uncomfortable for the operator's hand. Hot water offers the additional advantage of keeping the flap warm and pliable. Especially are ligatures to be avoided, since they are a source of irritation and prevent early union: pressure and torsion will usually obviate the necessity for their employment. When oozing is persistent, I do not hesitate to lay a few strands of silver wire beneath the lower edge of the flap, to avoid retention of blood, and make firm with cotton wadding and a bandage, removing the wire after a certain number of hours. Dissecting flaps from either side and sliding them to meet over a cavity is a certain way to ensure failure: where the line of union is supported from beneath success is attained, not otherwise; even the upper lip congenitally fissured gives an unseemly result when so treated; yet here there is partial support. The use of this procedure (sliding parts together) should be restricted to closing gaps left by transfer of skin to more distant parts; in other words, is complementary to the major operation. In order to facilitate the sliding of flaps lateral incisions are occasionally of assistance, but only when an ample blood-supply is at hand and scarring may be disregarded—a combination of circumstances found more frequently upon the body where habitually covered by clothing than upon the face. Transfer of skin with a pedicle is more frequently available. The pedicle should lie flat, and if transfer is made from a distance the intervening skin is to be cut so as to make a bed for the pedicle to occupy, thus assisting immediate union and giving nourishment to the distal part of the flap. Exceptionally only may a pedicle bridge intervening tissue, for usually it is taken from the border of the deformity. So far as possible, a pedicle should not be twisted, but it may be unavoidable: by forming the base of the flap judiciously, however, twisting is reduced to a minimum, and thus proper circulation ensured. If it so happen that a twisted pedicle remains elevated and unsightly, it can be pared and made to lie smoothly, but only after the flap has become well settled in its new situation, and vascular connection with surrounding parts established. Sensation after transfer of skin gradually becomes normal, although immediately after an operation it may be greatly

perverted. The raw surface left by transfer of flap demands but scant courtesy: it is in healthy tissue, so that all sorts of liberties can be taken with it. Usually the edges are very freely dissected up, slided the one toward the other, and united by suture, so as to form a linear scar: should tension be great, complete approximation is not attempted, and the intervening space is allowed to granulate. Granulating surfaces are best dressed with iodoform gauze and absorbent cotton; such a dressing may remain in place for a number of days. Where a small surface is so covered the removal of the dressing may expose a well-formed scar. If a flap fails to unite throughout, and healing by granulation be necessary, I use the same dressing. Raw surfaces are to be held together by suture; and of the various kinds I prefer the interrupted of silver wire passed with a straight needle: I do not, however, claim for it any special advantages over others. The pin suture so frequently used in plastic surgery I employ rarely. Whatever the suture used, or however used, one thing is essential: "there must be no tension on the lips of the wound," for if there is, the stitches cut out, leaving a ragged wound which heals slowly with an irregular scar. Tension, then, is to be avoided by free cutting—very free indeed—and by one or more deep sutures tied over quills or buttons. Such sutures are passed deeply at some distance from the wound, and are drawn tightly enough to place the flap-edge lightly in apposition with the proper surface previously denuded. There is then no tendency for the raw surfaces to separate, and union takes place rapidly. This is the great requisite to success, and it is easy to see of what small importance is the kind of suture used to unite the wound-edges, provided they already rest in apposition without tension.

Cases sometimes present themselves where from one cause or another it is impossible to achieve the desired result at once. A series of operations must then be performed, each one gaining a little, until success is brought about. The time intervening between successive operations depends upon the exigencies of the case, and follows no rule. Roux's well-known case may be quoted, as reported by Velpeau, where seven operations were performed, these in the end succeeding to the satisfaction of the operator. The extension of scar-tissue through the agency of multiple small incisions is too well known to require more than passing mention; and the same may be said of the necessity for giving rest to parts after operation by preservation of a suitable position. It is scarcely necessary to state that a plastic operation, be it never so simple, should be undertaken only when the patient is in excellent health; preparatory treatment is to be carried out by regulating digestion, putting the skin in order by baths, exercise, etc., etc.; for while it is true that but one part of the body is operated upon, yet all parts must contribute to a cure. Inasmuch as it is my habit to precede tedious operations by a hypodermic injection of morphine during preparatory treatment, I investigate the patient's susceptibility to the drug: especially is this necessary in children. Cool weather will always be more pleasant for both patient and operator than warm, and, as plastic surgery is rarely a matter of immediate necessity, summer—especially in town—should not be chosen as the time for operation.

ORAL SURGERY.

PART II.

By JOHN H. PACKARD, A. M., M. D.

Diseases of the Salivary Glands.

The salivary glands of the mouth—the parotid, submaxillary, and sublingual—are all liable to become diseased, and their affections are for the most part very similar. Yet the differences due to situation, size, and relation to surrounding parts are such as to make it more convenient to consider the disorders of each gland separately.

Parotid.—The parotid gland is liable to inflammation, which constitutes the disease commonly known as "mumps;" it is communicable from one person to another, often prevails as an epidemic, and one attack gives immunity for the future. For obvious reasons, this disorder is apt to be contracted in childhood, and is at that period less serious than in adult age. It comes on with chilliness, general aching, and discomfort; fever then ensues, and in a day or two there is dull pain at the back of the jaw, and swelling, which gradually increases until it interferes with the opening of the mouth. Both sides may be alike affected, or first one and then the other. Along with these symptoms there are depression of spirits and a sense of bodily weakness. The chief danger to be apprehended in these cases is metastasis to the testicle, which, however, rarely occurs, or to the brain, which is still more infrequent. Usually resolution takes place, all the symptoms disappear, and in from eight to twelve days from the onset of the attack the patient is quite well again.

The treatment consists in absolute rest, in allaying fever by appropriate means, and in the local application of hot fomentations or poultices. The "dry poultice," a sheet of raw cotton thoroughly heated and applied with oiled silk on its outer side, is very comforting. Liquid food should be given. Sometimes a state of debility follows, demanding the use of tonics.

When metastasis occurs to the testicle, that organ should be freely leeched and poulticed. Should the brain be attacked, the case becomes one of the greatest gravity, and demands the most vigorous treatment by counter-irritation, and all the other remedies proper in inflammations within the cranium, of whatever origin.

Besides this, there is occasionally, and especially as a sequel of typhoid fever or of scarlatina, inflammation of this gland, which very rapidly runs into suppuration. Abscess of the gland or of lymphatic glands

overlying it is also sometimes met with in connection with pyæmia; but whether as a cause or as an effect it is not always easy to say. Such cases are attended with great prostration of system, usually with delirium and fever, with a marked rise of temperature, particularly at evening; and the prospect is extremely unfavorable. Not unfrequently there is extensive swelling in all the neighboring tissues, and an unhealthy dusky flush of the skin, which is œdematous and shining. In a case of this kind which I saw with Dr. Murray Cheston in 1886, there was a sloughing abscess under the scalp also; the substance of the cheek was broken down, so that an opening formed into the mouth, and the pus discharged was horribly offensive; bare bone was felt under both abscesses, and the patient died exhausted in a few days from the onset of the disease.

Upon the first discovery of fluctuation, such abscesses should be promptly opened with a free hand; they should then be washed out with solution of bichloride of mercury (1 : 2000), and dressed antiseptically, with thorough drainage. The constitutional treatment should consist of ample nourishment, with quinine and iron; stimulants must be given as freely as they can be borne.

Tumors.—A variety of tumors may be met with in the parotid region: it is not always clear, when they come under the surgeon's eye, whether they have their origin in the gland itself or in the adjoining tissues. Fatty growths, or lipomata, are apt to be superposed upon it, and the same may be said of fibroids. Adenomata are much more apt to involve the gland itself, although they may be developed from the lymphatic glands overlying it. Cysts, sarcomata, and enchondromata usually arise in the substance of the parotid, as do also carcinomata; the latter are scarcely ever met with except in elderly persons. These varieties may often coexist in the same tumor. Perhaps the combination of cysts with sarcomata may be said to be most frequent.

Whatever the nature of the growth, an alteration of form is apt to be the first change noted. Pressure-symptoms come next; impairment of motion of the jaw, interference with the circulation, headache, and facial neuralgia. Later, and especially in what are known as the malignant forms of tumor, there is severe lancinating pain in the growth itself, which becomes irregular in form, and as a rule enlarges rapidly. The cervical lymphatic glands are often swollen and tender, and if the disease is unchecked, become the seat of secondary deposits. Mental depression is very apt to attend these cases, but the general health and nutrition are sometimes maintained until a very late stage.

The diagnosis in tumors of the parotid region is seldom easy, and sometimes presents great difficulty. But it may be said, in general, that rapidity of growth and early and severe pain belong rather to the so-called malignant neoplasms. To some extent, mobility of the new formation indicates its distinctness from the parotid, which is firmly enclosed and bound down in its dense sheath.

A guarded prognosis should always be given in these cases.

With regard to treatment, the main question is as to the feasibility of removal by operation. Procedures of this kind vary greatly in the degree of difficulty they present to the surgeon, as well as in the

amount of risk involved to the patient; nor can either of these be determined beforehand. Very large tumors are sometimes outside of the parotid, and concern no important structures; while small ones may occupy its substance, dip into the intermuscular spaces, and be closely connected with large vessels and nerves.

Should excision be decided upon, it must be done under strict antiseptic precautions. No uniform line of incision can be prescribed, but the wound should be so made as to afford free access to the growth, and to admit of subsequent drainage. Complete ablation of every discoverable atom of diseased structure must be the surgeon's aim. The best plan is to work from below upward, the patient lying with the head raised, thrown back and to the sound side, so as to fully expose the affected region. Much of the dissection may be best done with the knife-handle or with a blunt knife, or with an artificial nail worn upon the surgeon's finger. All vessels should be tied as divided; nerves should be spared if possible, being held out of the way with blunt hooks. If any portion of the facial nerve is sacrificed, paralysis of the parts supplied by it is apt to be permanent. The after-treatment presents nothing special, but I think it is well always to feed the patient by the rectum, for a few days at least.

Operations of this kind are not to be lightly undertaken: in some cases all interference with the knife should be firmly declined.

Submaxillary.—The submaxillary gland is much more liable to ordinary inflammation than the parotid. Very often the gland on one side is in a state of chronic enlargement, and becomes slightly tender whenever the patient "takes cold." Its smaller size, more isolated and protected situation, and perhaps the absence of pressure, render it less liable to the diseases described as affecting the parotid. It is, however, not unfrequently the seat of secondary deposits in cases of epithelioma.

The same remarks apply to the *sublingual* gland.

I have never seen a case requiring the removal of either of these organs, except in connection with cancerous growths of the tongue, and then the procedure is only a part of a much more formidable one. In fact, cases involving them are very generally beyond the reach of relief from operation.

Salivary calculi are found most frequently in the duct of the submaxillary gland. They are composed of carbonates and phosphates, with inspissated mucus, and if of any size are moulded by the walls of the tube into a cylindrical shape. Sometimes, as in a case seen by me a year or two ago, a very little mass of this kind will be caught at the narrowed orifice of the duct and form an obstruction to the flow of saliva through it. Or there may be gradual accretion, and the calculus may acquire a considerable volume before its presence is ascertained, the saliva not being wholly obstructed even then.

The patient experiences a certain amount of annoyance, as if from a foreign body, and the duct becomes swollen, the gland itself sometimes partaking in the enlargement. On putting one finger on the floor of the mouth at the side of the tongue, and opposing it with another on the outside and below, the calculus is readily felt like a piece of slate-pencil. An incision may be made through the wall of the duct upon

it, and it may be carefully extracted either by pressure or with forceps. The brittleness and friability of these formations make it necessary to give plenty of room for their escape, as, if they break, some sharp fragments may remain and cause irritation, besides constituting a nucleus for fresh accretions. Although not very painful, such an operation is best performed under ether.

When calculi form in the duct of the parotid the removal is effected in the same way, by an incision on the inside of the cheek.

Very small calculi may sometimes be simply expressed through the orifice of the duct.

Salivary Fistula.—This is a very troublesome affection, which may result from wounds or abscess, or from incautious surgical procedures. It consists in an outward opening from the duct of Steno, so that the saliva flows either partially or altogether over the cheek instead of into the mouth. During the periods of activity of the gland this is especially annoying, and the skin becomes excoriated.

Various methods have been adopted for the relief of this condition, but the object to be attained is the same in all. A free opening must be made into the mouth and maintained, while the orifice in the skin must be closed.

The simplest method is the following: The orifice of the duct being brought into view, a needle armed with a silk ligature may be passed into it, and pushed through the wall of the duct into the mouth, so as to include a full quarter of an inch of the tissue of the wall; the other end of the silk is then carried into the mouth, and the two ends are tied together. Next, the edges of the wound in the skin are carefully pared, one being bevelled outward and the other inward; and they are accurately apposed with sutures. The employment of antiseptic precautions and dressings will probably be found to ensure union by first intention. Should a minute orifice remain from trickling through of saliva, it may very probably close after one or two applications of a heated needle.

Descriptions of the other plans proposed may be so easily found in works on surgery that it scarcely seems needful to enumerate them here. The affection is so rare that many surgeons have never met with it in long years of practice.

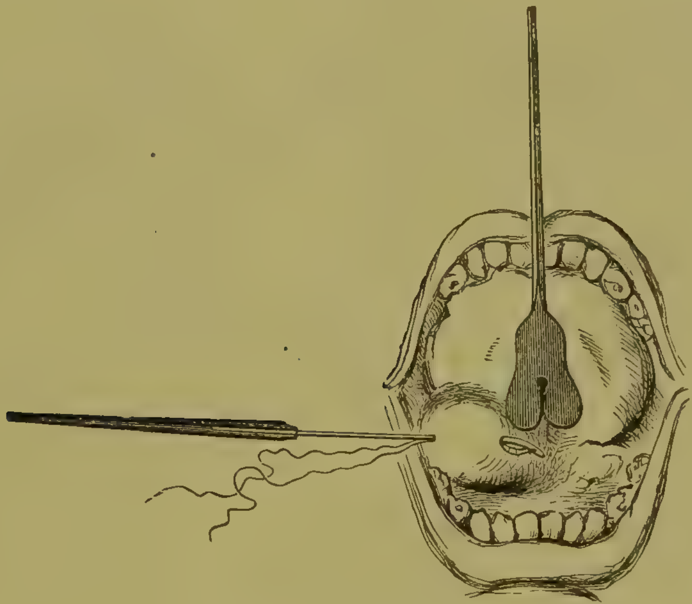
Ranula, although by many writers described as an affection of the sublingual gland, is probably always a retention-cyst formed from one of the mucous follicles of the floor of the mouth. It is most frequently met with in children, and may be unnoticed until it attains a large size.

It forms a fluctuating swelling, with thin and somewhat opalescent walls, below and at one side of the tongue, which is sometimes pushed upward and impeded in its movements. A plan of treatment which has been sometimes found successful is the passage of a seton of silk thread in the manner shown in the cut. The needle being withdrawn, the ends of the silk are tied together, so that the thread lies loosely through the sac, and serves as a drain to evacuate its contents, after which the irritation excited by its presence causes adhesion between the walls of the sac and obliteration of its cavity.

Another plan, shorter and perhaps equally if not more efficient, is the free excision of the thin anterior wall of the cyst.

There is another form of cyst spoken of by some authors, which seems more likely to be the remains of a fœtal structure. Its walls are much thicker and denser, and its contents are cheesy, like those of the seba-

FIG. 207.



Operation for Ranula.

ceous cysts elsewhere observed. Cysts of this kind are more deeply imbedded in the intermuscular space at the floor of the mouth, and may be felt below the jaw. The treatment consists in incision (from without or through the mouth), thorough evacuation, and stuffing the cavity with borated or other antiseptic lint.

Diseases and Injuries of the Tongue.

Tongue-tie, or abnormal shortness of the frænum linguæ, is a condition often supposed by mothers and nurses to exist in the children under their care, and to hinder sucking; but in reality it is very seldom a source of trouble. The opposite condition, absence or undue length of the band, although very rarely noted, is said to have occasioned death by suffocation, the tongue falling backward so as to occlude the laryngeal opening.

When the frænum is really too short, it may be cautiously clipped partly through with a pair of scissors curved on the flat, the points being directed downward and the tip of the tongue held upward and backward with the cleft handle of a director, as in the operation for ranula. (See Fig. 207.) This procedure has been resorted to in some cases of youths or adults in whom defects of speech have been thought to depend upon the malformation in question, and good results have been claimed for it.

When the tip of the tongue is too free, nothing can be expected from any surgical treatment. By careful watching, trouble may be prevented

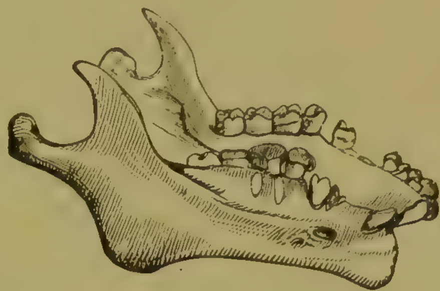
until the period of infancy is past, when the development and acquired control of the muscles will set the danger aside.

Hypertrophy of the tongue, or *macroglossia*, may either be congenital, or at least may be first noted in early infancy, or it may come on in

FIG. 208.

Macroglossia.

FIG. 209.



Effect of Macroglossia upon the Teeth.

adults; in the former case it is apt to be associated with mental weakness or even idiocy. It appears to be due to obstruction of lymph-channels, and thus analogous to affections seen in other parts of the body, as in many cases of so-called elephantiasis. The blood-vessels may be much dilated, but the bulk of the tumor consists of connective tissue and lymph-spaces.

Speech is not very much affected, but the taking of food is interfered with, and, as the organ must grow forward, it pushes against the lower jaw and crowds the incisors into a horizontal position, as in Fig. 209. The protruded tongue keeps the lips open, and the saliva, which is apt to be secreted in undue quantity, flows away constantly. The dorsum of the tongue becomes dry, cracked, and sore.

In the early stages of the disease, which advances slowly, iodide of potassium may be tried, and astringent lotions; benefit has been ascribed also to keeping the mouth closed by means of a bandage or other appliance, except at meal-times. Removal by knife or scissors is, however, much more effective, although it may have to be repeated if the growth recurs.

Atrophy of the tongue has been observed, especially as affecting one-half only of the organ. It seems to belong among the trophic nerve-lesions; its symptoms are set forth in its name, and there is no known treatment to which it is amenable.

Reference may be made here to certain surface-changes not unfrequently noticed in the tongue.

Dyspeptics are very liable to present *bare spots* of irregular outline, or fissures, which may be merely linear deficiencies of epithelium, or may be actual cracks in the mucous membrane; these lesions usually disappear under successful treatment of the general condition, but are apt to recur again and again.

One side of the tongue may be more or less heavily furred, the other remaining clean or nearly so. I know of no satisfactory explanation

of this, nor of the *black fur* observed in some patients. I have long attended a gentleman, now about seventy years of age, who has had various manifestations of a gouty diathesis and several attacks of catarrhal pneumonia, and have repeatedly had occasion to note the fact that his tongue for months at a time presented a deep brown, almost black, discoloration over a large part of the dorsum. It seems to be without special significance.

Wounds.—The tongue is sometimes wounded by being caught between the teeth. This is especially apt to happen in epileptic attacks, but children occasionally sustain such injuries in falling. Accidents may occur also during the performance of dental operations, causing injury to the tongue, especially by the incautious use of sharp corundum disks rapidly revolved by the dental engine. The tip and sides of the organ are of course more liable to be hurt in any of these ways than its more central portions. Usually, the lesion is slight, and healing readily takes place. When, however, the tongue is deeply divided, there may be very copious bleeding, which must be checked; or the wound, left to itself, might heal without closing, and a very ugly gap would remain in the organ, perhaps affecting speech.

When the bleeding is only venous oozing, it may suffice to apply a bit of ice, or to make pressure with a little wad of lint dipped in very hot water.

In severe cases, when an artery is divided, the patient must be placed in a good light, and the mouth widely opened by means of one or other of the gags elsewhere described. The tip of the tongue should then be drawn forward, either with forceps or with a strong hemp or silk ligature passed through it, and the wound inspected, when any bleeding points may be caught up and tied. The wound may now be closed with as many sutures as may be needed, passed deeply and tied on the dorsum: for this purpose, as well as for securing the vessels, chromicized catgut answers well.

Occasionally it happens that the tongue is stung by insects taken into the mouth along with fruit, and some inflammation may ensue; but it is not generally of much moment.

Foreign bodies are sometimes imbedded in the substance of the tongue. During the late war I attended an officer shot through the mouth, several teeth being carried away. An abscess formed in the tongue, and closed and reopened several times: on exploration with a probe I found and removed a piece of a tooth, and permanent healing at once took place. Seiler met with a case in which severe inflammation, involving the fauces, was caused by a bristle from a toothbrush sticking into the substance of the tongue; on its removal the trouble at once subsided.

Glossitis.—*Inflammation of the tongue*, or *glossitis*, is not now a common affection, although in former days, when mercurial salivation was often aimed at in medical treatment, it was constantly to be observed. Its causes are not always easy to determine.

The symptoms are marked swelling, heat, and tenderness of the organ, which fills the mouth and may even project between the lips; fever and severe constitutional disturbance. Eating, and even breathing, are greatly interfered with.

The treatment consists in free longitudinal incisions, which are promptly effectual in setting aside all the symptoms. Warm mucilaginous mouth-washes, with borax or soda, and antiseptics if the secretions of the mouth are offensive, will be of advantage. Healing of the cuts takes place very readily.

Dyspeptics are very liable to irritation of the tongue, which may take the form of abrasion or very superficial ulcer. Relief of the causal condition is followed by disappearance of the local lesion.

Aphthæ.—The *aphthous* ulcer is more frequently met with in children, but occasionally in adults also. It belongs to the condition of debility; begins as a small white blister, which is broken, and leaves a round, smooth, raw surface, extremely tender. These sores are always multiple, and usually exist on the gums and on the inner surface of the lips and cheeks, as well as on the tongue.

Stimulants, as myrrh, sweet spirits of nitre, solution of alum, or borax and honey, may be used locally. If the tenderness is excessive, a 4 per cent. solution of cocaine may be brushed over the ulcers. But corrective remedies must be addressed to the stomach, and tonics to the system at large, in order to effect a cure. In these cases, as indeed in every form of ulcer of the tongue, the diet is to be carefully regulated; very hot or very cold articles should be avoided, and in general acids and acescent foods, condiments, and sweets. The effect of any strong cheese in aggravating the trouble is often marked. Adults should be cautioned to abstain wholly from tobacco.

Vascular Tumors.—*Nævus*, or *angeioma*, has in a few instances been seen in the tongue at or soon after birth. It varies, as in other situations, according to the predominance of the arterial or venous element in its composition. There can scarcely be any difficulty in recognizing its character; it forms a more or less deeply purple prominent patch upon the dorsum—can be emptied by pressure, but promptly refills.

As elsewhere, these growths sometimes disappear spontaneously; but the proper course when they are of any considerable size, and especially if they are increasing, is to destroy them by means of the cautery at a dull red heat. Paquelin's instrument, or a small iron, may be used. The former, which is shown in Fig. 210, consists of a blunt blade, *G*, connected by a handle, *F*, with the tube of an atomizer. In the bottle, *C*, is some rhigolene, which is driven through in spray into the blade by compression of the hand-ball, *E*. The blade, having been heated in the spirit-lamp, *A*, is kept at the desired temperature by the combustion of the rhigolene vapor. At *I* is shown a cautery of button-shape, to be used for suppressing hemorrhage, burning out small warts, etc. Neither the ligature nor the ordinary knife is available in these cases; the wire écraseur might possibly answer sometimes. The parents should be warned that the operation is not free from risk.

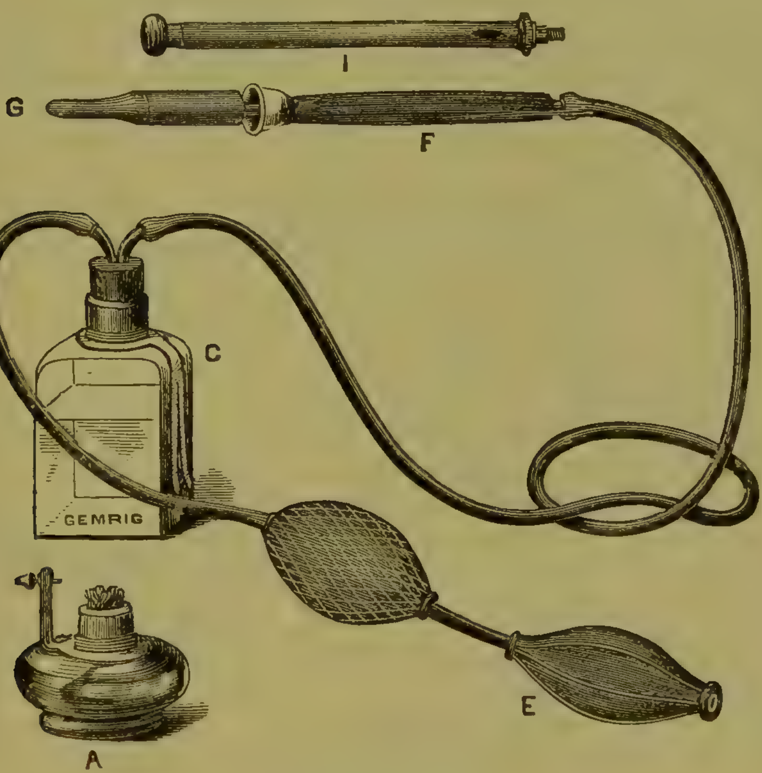
Ulcers.—Ulcers of the tongue may be caused by the pressure of sharp or ragged edges of the teeth. I have several times been applied to by elderly persons on account of deep and painful ulcers on the side of the tongue, with the idea that they were affected with cancer; but the sores promptly healed on the removal of molars which had been worn down to a sharp edge, against which the tongue had been continually fretted.

When such teeth are sound, the filing away of the sharp edge or of any points which may be felt may be first tried before resorting to the severer measure of extraction.

Tuberculous ulcers of the tongue are not very frequently seen, and are but a manifestation of the general disease. They are described as indolent, flabby sores, apt to be seated near the tip of the organ; they are very little amenable to local treatment, and indeed must be regarded as evidence of the gravity of the systemic disorder. It is only by their association with other phenomena that the tuberculous nature of these lesions can be determined, and to those other phenomena must medication be directed.

Palliative remedies may be applied to allay pain in these ulcers: iodoform, morphia, cocaine, and aconite have been thus used, and sec-

FIG. 210.



Paquelin's Cautery.

tion of the lingual nerve has been suggested in case of the failure of all other means.

Warts.—Warts of the tongue are occasionally seen: they consist of abundant proliferations of epithelium, with hypertrophy of the papillary structures beneath them. They are chiefly notable on account of their tendency to become the starting-point of malignant growths, and I believe that their early and thorough removal by means of the knife or galvano-cautery should always be recommended.

Lupus of the tongue has been so rarely observed, and the characters of the disease differ so little from those belonging to it elsewhere, that it need only be mentioned as of possible occurrence.

Syphilis.—Syphilitic affections of the tongue are by no means rare.

They belong for the most part to the later stages of the disease, and the history of each case, with the fact of other lesions, will almost always make the diagnosis quite clear. Positive certainty is generally afforded by the curative effect of antisyphilitic treatment.

The earliest and commonest syphilitic lesion observed in the tongue is the *mucous patch*—a bluish or grayish-white, smooth area, often multiple, irregular in shape, slightly raised, and painless. Occasionally each patch is cracked or fissured, and there may be irritation from contact with the teeth or perhaps from gastric disturbance. These patches, from which the systemic disease may be communicated, are associated with the secondary stage—that of phenomena affecting the skin, mucous membranes, and hair.

The *plaques* or *patches* of tertiary syphilis are apt to be larger, more raised, of a deeper color, often red, and are not known to be contagious. They are not always easily distinguished from *gummata*, which form in the substance of the tongue, sometimes superficially, sometimes deeply, and which may by their softening and breaking down give rise to true *syphilitic ulcers* of the tongue. These are ragged, deep, irregular sores, with a tendency to form grayish sloughs, and discharging very offensive muco-pus.

In general terms, it may be said that these lesions are amenable, in the secondary stage, to preparations of mercury; in the tertiary, to the iodide of potassium; and in both, to active tonic and supporting treatment, with cod-liver oil and generous diet. Locally, disinfectant washes, astringents, and, if there is pain, anodyne applications, may be employed with some degree of benefit.

Tumors.—Various forms of tumors are met with in the tongue. The benign are cysts, fibromata, lipomata or fatty tumors, and enchondromata. All these are troublesome only by their bulk and by the apprehensions they create in the mind of the patient. They are usually of slow growth, and may be removed without fear of return. Cysts may be freely opened, and the inner surface cauterized with Paquelin's instrument or with an iron at a red heat. The other forms of tumor can be excised either with knife or scissors.

Malignant tumors of the tongue are generally carcinomatous, and of the variety known as epithelioma. Sarcomata are of very great rarity.

These tumors may begin as plaques, as patches of psoriasis or ichthyosis, or as warts. Commonly their growth is rapid, and attended with severe lancinating pain; ulceration occurs sooner or later, with foul discharge, the sore having ragged and irregular edges and a deep, tender, indurated base.

Early removal affords the only chance of essential benefit. Ligation of the lingual artery has sometimes been tried with the view of causing atrophy of these growths, but not with encouraging results. The lingual nerve has been divided, with temporary relief of pain and arrest of salivation.

Amputation or Excision of the Tongue.

For any operation on the tongue anæsthesia is required, not only to save pain to the patient, but to enable the surgeon to exert complete control of the organ. But for obvious reasons there must be difficulty in maintaining it, and generally the operation must be now and then suspended in order to allow full inhalation for a few moments. When the heated iron or the galvano-cautery is to be used, the inflammability of ether involves a serious danger, and chloroform is to be preferred. A prudent surgeon will, however, see that brandy, ammonia, and a galvanic or electro-magnetic battery are at hand; he will entrust the administration of the chloroform to a careful and experienced assistant, and will arrange for proper measures to be instantly taken should syncope occur.

When there is reason to suppose that the operation to be performed will be especially complicated, protracted, and bloody, it may be well to provide against embarrassment by a preliminary tracheotomy. This not only affords independent access for the anæsthetic vapor, but enables us to prevent blood from flowing into the air-passages (to some extent also from being swallowed) by placing in the pharynx a carbolized sponge of suitable shape and size, having attached to it a strong ligature by which to control and withdraw it.

Fig. 211.

Trendelenberg's Tampon-canula, with arrangement for anæsthesia.

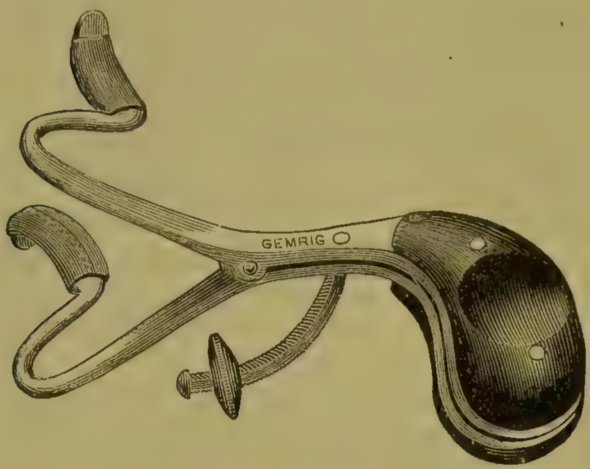
Or Trendelenberg's tampon-canula (Fig. 211) may be used. This consists of a canula or tracheotomy-tube, *a*, having around its inner end a tubular bag of soft rubber, which can be inflated through the tube at *b* by compressing the attached bulb. The anæsthetic is administered through another rubber tube connected at *c* with an inhaler and opening into the tracheotomy-tube.

Whichever of these plans may be chosen, the assistant in charge of the anæsthetic should be very thoroughly experienced, and should give his whole attention to this special matter alone during the entire time occupied by the operation.

In many of these cases the mouth must be kept widely open. Most of the gags in use for this purpose are adapted for the operation for cleft palate, and are arranged to press the tongue down; but here the

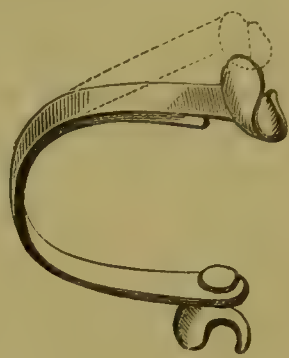
tongue must be left free, except as controlled by the surgeon. Mason's instrument (Fig. 212) or Hutchinson's (Fig. 213) will answer well. It is best to have two, one on either side.

FIG. 212.



Mason's Gag.

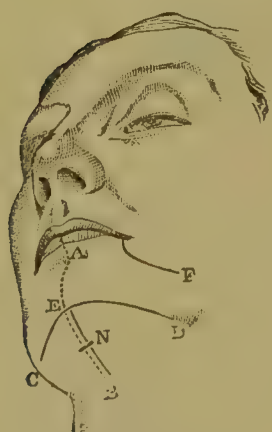
FIG. 213.



Hutchinson's Gag.

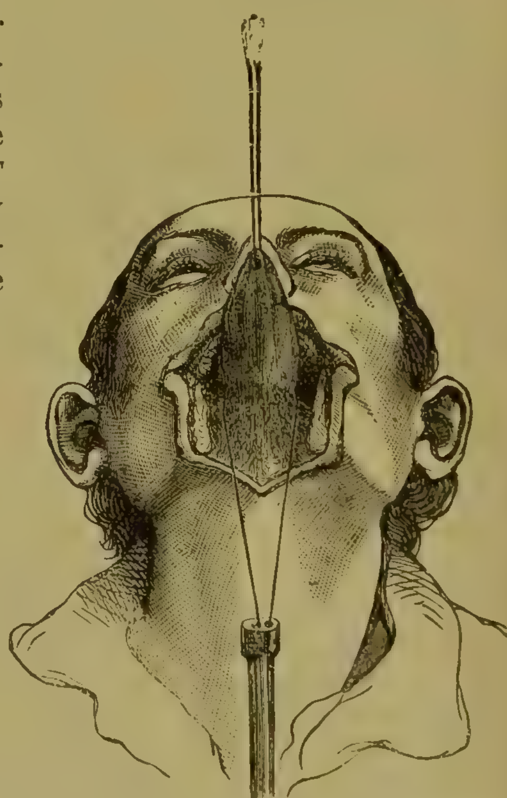
When the disease involves only a small portion of the tongue, sufficiently free access may be had by the mere opening of the mouth; but if the growth is more extensive it may be necessary to expose the organ more completely by incisions. For this purpose either one of three different plans may be adopted: One is to lay the cheek open from the angle of the mouth outward to the point *F* (Fig. 214), taking care to go below the duct of Steno. In the cases requiring operation the age of the

FIG. 214.



Incisions for Exposure of Tongue.

FIG. 215.

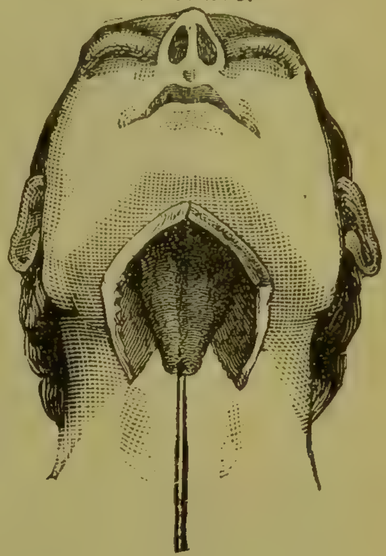


Removal of Tongue with Écraseur by Division of Lower Jaw.

patients is generally such that some of the teeth are likely to have been lost, and thus gaps are left through which instruments can be very readily applied. When this method is used the gag is adjusted on the opposite side.

Another plan, not now often put in practice, is to split the lower lip and chin from *A* to *B* in the median line; then to saw the bone through at the symphysis, and to divide the muscles of the floor of the mouth, so as to enable the surgeon to separate the two halves of the bone laterally (Fig. 215). Very free access is thus given to the tongue, which can be drawn forward and downward. After the operation is completed the bones are brought together again and united by one or two sutures of silver wire or of strong catgut passed through holes drilled for the purpose.

Fig. 216.



Tongue drawn out between the Jaw and Hyoid Bone.

The third method is by what is known as Regnoli's incision: it consists of two cuts—one, *CED*, just within the arch of the lower jaw; the other, *EB*, antero-posterior and in the median line from the middle of the former to the hyoid bone (Fig. 214). Through the gap thus made in the floor of the mouth the tongue can be turned down and brought out, as in Fig. 216.

In selecting a method of incision the surgeon must be guided by the extent of the disease, the degree of mobility of the tongue, and other considerations which may present themselves in special cases. When the glands at one side of the diseased organ are involved, it may be desirable to get a freer opening in their neighborhood, and for this purpose a good plan has been adopted by Kocher (Fig. 217). An incision is made along the anterior edge of the sterno-mastoid muscle from just below the tip of the ear to the level of the hyoid bone; then inward to the middle of the body of this bone; then forward to the jaw. On turning up the flap thus described, and tying the vessels, the extirpation of the diseased structures may be thoroughly made. It is best to work from behind forward: either the knife, the scissors, or the galvano-cautery may be used.

Fig. 217.

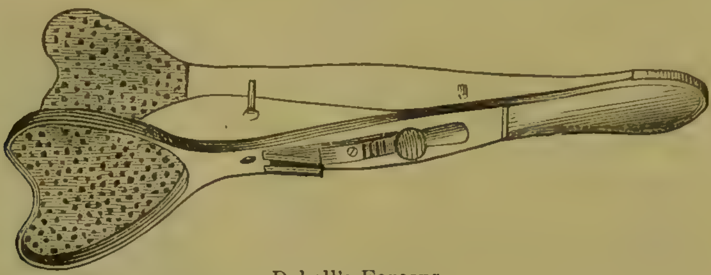
Kocher's Incision for Exposure of Tongue.

Some of these operations on the tongue have been done with a very small incision just in front of the hyoid bone, a ligature being passed up into the mouth, over the tongue, and down so as to emerge through the same opening. By means of this ligature the chain of the écraseur was drawn into place and the tongue divided, when with scissors or knife the anterior part was separated from its attachments and removed. This plan has very little to recommend it except where the limits of the disease are very sharply defined.

For the purpose of controlling the movements of the tongue during operations the simplest plan is to pass a strong ligature of thick hemp or silk thread through its substance near the tip; sometimes two are

used, one on either side of the middle line. Dobell's forceps, having perforated zinc blades (Fig. 218), are apt to injure the tongue by bruis-

FIG. 218.



Dobell's Forceps.

ing it, more than the ligature. For operations of short duration it may suffice to employ a tenaculum or a volsella forceps.

When tumors, of whatever kind, are to be removed from the tongue, the patient being anæsthetized and the mouth opened and fixed thus with a gag, the tongue is drawn forward into such a position as to expose the growth. If this is imbedded in the tissues, it is seized with volsella forceps, drawn into prominence, and then separated by clipping around it with a pair of scissors curved on the flat. Should bleeding follow, it may be checked by pressing a pad of lint dipped in hot water or hot alum solution (ʒj to f℥iv) into the wound. Any vessel detected is to be tied. Astringent and disinfectant washes must be used until the wound heals, to prevent the fetor of the secretions of the mouth.

Should a portion of the tongue itself require removal, as in cases of macroglossia, a strong ligature is passed through the organ behind the proposed line of division: by this means it is drawn forward, and a suitable piece, generally wedge-shaped, is quickly cut away with a knife. As a rule, the incisions defining the wedge are vertical and converge at the middle line. But it is said that sometimes the tongue is thickened so greatly in its vertical diameter as to compel the taking out of a horizontal wedge. This condition, which I have never seen, would probably be met by the removal of a wedge with a somewhat lozenge-shaped section; or a second operation might be done if there were still too much tissue in the vertical diameter after the healing of the wound first made. In fact, however, the depletion from any section performed in the manner first described would be apt to cause a considerable shrinkage in the volume of the organ, and might flatten it sufficiently.

When cancer affects the anterior portion of the tongue only, the scissors or knife may be used for its removal, the bleeding met with being readily controlled by hot water and direct pressure; or the galvano-cautery can be applied with great advantage, and without any bleeding at all if the heat of the wire be properly regulated.

The ligature, formerly in common use in these cases, has now been totally abandoned, with reason; for the sloughing mass remaining in the mouth was very offensive, and sometimes gave rise to blood-poisoning.

Removal of the whole tongue or of the greater part of it is in general merely a palliative operation. Yet the benefit derived from it is often

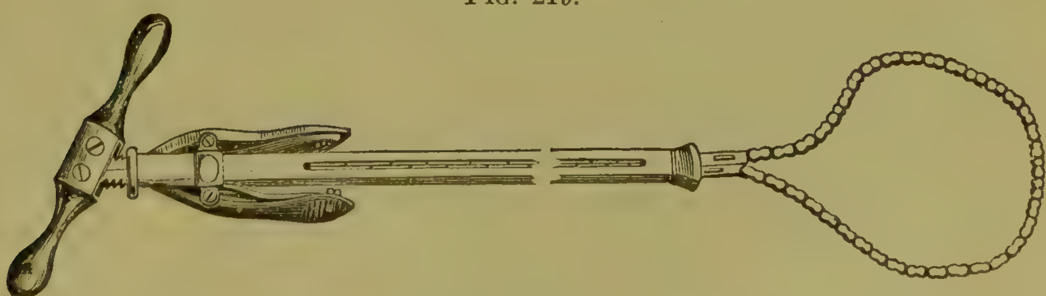
very marked, and occasionally extends over a long period of time. Certain dangers, however, which ensue upon all such procedures should make the surgeon cautious in his promises to the patient, and still more cautious in his treatment. Chief among these is pneumonia of a low type, probably from blood-poisoning. Septicæmia without special local lesion has also occurred under such circumstances. Secondary hemorrhage cannot always be guarded against.

The patient should be prepared for the operation by a few days of treatment, bringing the secretions into good order. A mild mercurial purge, followed by gentle laxatives at bedtime for two or three successive nights, may be prescribed; a carefully regulated diet of the most nutritious and easily assimilated liquids, with quinine in moderate doses; anodynes if sleep is much disturbed; and assiduous cleansing, so far as it is possible, of the oral cavity by means of antiseptic washes thoroughly applied;—all this will go far to promote a successful issue.

Before the operation is begun the face should be thoroughly shaved, unless, as in some women, the skin is free even from down. The skin should then be rendered absolutely clean by the usual methods, and the mouth washed out with bichloride solution, 1 : 2000. (It may seem as if these precautions were idle in dealing with a cavity like the mouth, where there is an incessant shedding of epithelial scales and where bacterial organisms are always present; but they certainly reduce the chance of mischief.) Complete anæsthesia having been induced, through the tracheotomy-tube if this operation has been performed as a preliminary, the tongue is drawn forward, and a strong carbolized silk ligature passed through its tip or as near it as the disease will allow. Next, if necessary, the cheek or the floor of the mouth is divided, and any bleeding from the wound so made is arrested. I always make these incisions obliquely, so as to obtain more ready and perfect healing; in one case the divided cheek was completely united on the third day, with a scar which was a mere hair-line, scarcely perceptible.

The tongue is now drawn to one side and the other, and freed by touches with the knife, so that the whole of the diseased structure can be reached, and a little beyond it. If the incision has been made

Fig. 219.

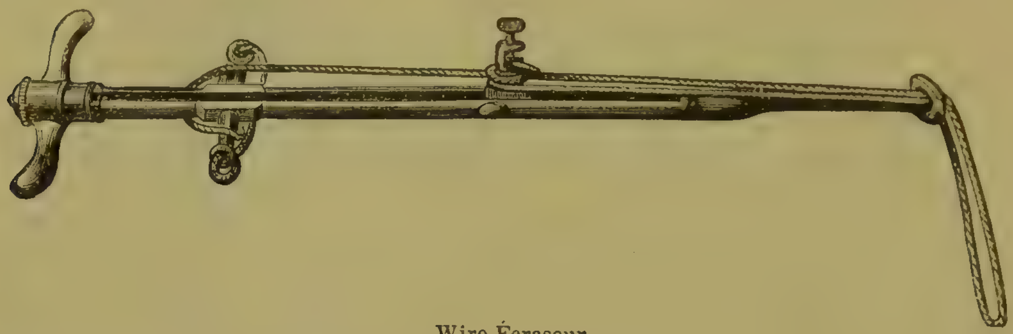


Chain Écraseur.

through the cheek, the mouth is fixed wide open with a gag between the jaws on the opposite side, and the tongue is drawn forward. When either of the other plans has been selected, the organ is drawn down so as to expose it outside of the mouth. It is now transfixed by two strong

needles at right angles to one another, and the chain or wire of the écraseur or the wire of the galvano-cautery applied around it behind these. As the tissues are severed, the surgeon or a sharp-eyed assistant should be on the watch, and, if any vessel springs, should either

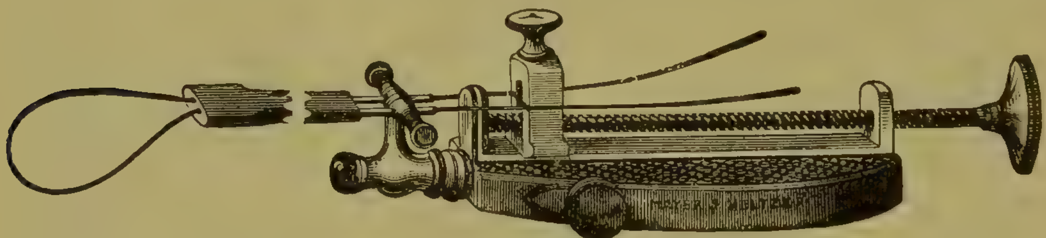
Fig. 220.



Wire Écraseur.

catch it with a tenaculum and apply a ligature, or put a pair of catch-forceps on it. The severance completed, the stump should be caught with a ligature passed by means of a curved needle and carefully scanned. Any oozing of blood should be stopped with hot water,

Fig. 221.



Galvano-Cautery.

and the soundness of the tissue left should be clearly ascertained. Care must be taken in letting go of the stump, as it may fall back and occlude the air-passage. Should this be threatened, the ligature already passed through the stump might be brought forward and secured to one of the teeth.

Everything being found as it should be, the whole cavity of the mouth must be thoroughly cleansed, and the wounds closed by sutures, after which an antiseptic dressing is applied as in any ordinary case.

Sometimes, after transfixing the tongue with the pins, a strong, thick ligature has been tied round the organ behind them, just tightly enough to hold its place, the diseased part being then amputated with successive cuts of the knife or scissors, and any vessels tied as they spring. The ligature being then slackened, all further bleeding is checked and the pins are removed. This is a more tedious and difficult procedure than the other, and almost certainly involves a greater loss of blood.

During the performance of the operation after either of these methods, unless a preliminary tracheotomy has been performed, the operator will be obliged frequently to pause for the renewal of the anæsthesia; but this is not always a disadvantage, as the tissues are under continual compression, and the loss of blood may be lessened by the delay.

Besides the chance it affords of keeping up the anæsthetic influence,

an opening in the trachea has the great advantage of enabling the surgeon to carry out much more complete antisepsis in the oral cavity after the operation. Breathing being carried on through the artificial orifice, the mouth may be dusted with iodoform and aseptic dressings applied to the surface of the wound. There can be no question that this course would lessen the chance of blood-poisoning or of pneumonia; and the additional risk involved in the tracheotomy itself would be too slight to be taken into the account.

For a few days after the operation of removal of any considerable portion of the tongue it is better, if not indispensable, to nourish the patient by the rectum, giving peptonized liquids, as milk, beef-juice, or some other of the prepared foods. Medicines, if required, may be given by the same channel or hypodermically.

In cases of disease not extending beyond the median line of the tongue the sound half of the organ need not be interfered with. Here the knife or scissors can be employed to excise the affected part, exposed by drawing the tongue out and to the opposite side. Any vessel seen bleeding may be tied, and oozing may be checked by firm pressure with a plug of lint soaked in very hot water or alum solution.

Believing, as I do, that sulphuric ether is in general much safer as an anæsthetic than chloroform, I should always employ the former except where its inflammability would involve risk. When the diseased tongue is severed by the galvano-cautery, if the wire is placed cold in a groove previously made with the knife, and the current then passed, the contact with moist tissues in which the wire imbeds itself will probably prevent any trouble. Yet with all the care possible the ether vapor may take fire; and hence, when either the galvano-cautery or the Paquelin knife or any heated iron is to be used, I would employ chloroform as the anæsthetic, taking all the precautions before mentioned in case of syncope ensuing.

Possibly another danger attends the use of ether in these cases. It will be remembered that pneumonia was mentioned as a frequent cause of death after removal of the tongue. One of the well-known consequences of the inhalation of ether is the production of more or less marked congestion of the lungs; and this condition, continuing, may readily pass into actual inflammation, grave from the very fact of its extent. Similar risk may attend the use of chloroform, but I think not in the same degree.

Secondary hemorrhage occasionally happens after operations for the removal of the tongue. It is more apt to follow the rapid division of the tissues by the galvano-cautery than the slower methods. Such bleeding may be temporarily arrested in the manner proposed by Heath—by passing the finger far back along the side of the mouth, hooking it behind the hyoid bone, and pulling forward: in this way the lingual artery is compressed, and time may be taken to find the bleeding orifice, when it can be tied, or a cautery iron at a black heat applied. Effectual means must be adopted, because the patient will almost certainly have swallowed some blood, and vomiting will be very apt to occur, during which fresh hemorrhage may take place.

Injuries and Diseases of the Lips.

Wounds of the lips are not uncommon. They may be incised, lacerated, or contused; the mucous membrane nearly always suffers from contact with the teeth; indeed, the substance of the lip may be cut clear through by the teeth from a blunt body striking the mouth.

Very free bleeding may take place in such injuries, but rarely to a dangerous extent. Usually hot water will soon check it. (I once saw an infant, to all appearance healthy, bleed to death from a scratch of the lip received on the sixth day after its birth: nothing availed to stop the flow, and the child died exhausted in eight days.)

Incised wounds should be neatly brought together, the hare-lip or pin suture being more secure than any other. Catgut sutures will answer if the cut does not go clear through, and sometimes a good result can be got with adhesive plaster. The great object is to avoid deformity; if this occurs, it can often be remedied by a plastic operation.

Carbuncles affecting the lips, especially the upper one, are in general attended with great constitutional disturbance, and have repeatedly proved fatal. Prompt and free incision, antiseptic poultices or dressings, with tonics and stimulants, constitute the proper treatment.

Ulcers in this region are generally due to herpes or to cracks caused by cold weather. The chief obstacle to healing is the mobility of the parts. Drying salves, such as that made with oxide of zinc, should be used; the occasional application of sp. nit. dulc. will hasten the cure.

Sometimes ulcers are the result of mucous patches belonging to the secondary stage of syphilis; the history of the case will then aid the diagnosis, which will be established by the disappearance of the sore under antisyphilitic treatment.

Tumors of the lips are not uncommon.

Hypertrophy, a very disfiguring enlargement, usually affects the lower lip, and is apt to be associated with a red discoloration of the skin, known as wine-mark—a nævoid dilatation of the capillary blood-vessels. The only remedy is by a plastic operation, which must be modified to suit each case. It must be remembered that no such procedure can be wholly free from danger, and of this fact the patient ought always to be notified beforehand.

Fig. 222.

Macrostoma.

Macrostoma, a fissure extending outward from the angle of the mouth through the cheek, is the result of defective development. It has sometimes, but rarely, been seen affecting both sides of the mouth.

The treatment consists in paring the edges of the cleft, and bringing them together by suture, as in the case of hare-lip.

Exactly the opposite condition is sometimes caused by the healing of burns or other injuries of the lips, the orifice of the mouth being greatly reduced in size, and perhaps distorted. Along with this there are apt to be adhesions of the lip to the gum, perhaps at various points. Such a condition not

only gives rise to most repulsive deformity, but interferes in a very serious degree with speech, with the taking of food, and even with respiration.

As a general rule, these cases demand great patience on the part of the sufferer as well as both ingenuity and patience on that of the surgeon; but they often admit of much improvement. One of the difficulties apt to be in the way is the loss of normal structures, so that the mere restoration of shape does not also restore function. Another is the strong tendency to recontraction and to the renewal of divided adhesions. Repeated operations are often necessary, and occasionally the final result is disappointing.

It would take a very large space to discuss even briefly the details of these procedures, and of the means taken to secure the advantages as they are gained. The reader will find information on all these matters in works on plastic surgery, and in the many monographs on special cases which have from time to time appeared in medical periodicals.

Nævi, angeiomata, or *vascular* tumors are of frequent occurrence in the lips, more so in the lower than in the upper. They present the same characters as in other localities, but from the abundant supply of blood-vessels to this part are apt to be deeper in color and their constituent vessels larger than elsewhere. Usually the entire thickness of the lip is involved, and the growth often extends also to the gums, and even to the tongue. Pulsation is sometimes to be observed in the mass.

Children are the usual subjects of this disease, which is rarely seen in adults, because it is not allowed to remain. The recognized treatment is by surgical operation—ligation or cautery in the case of small and superficial tumors, excision when they are large and deep.

These procedures, however, are by no means free from risk: I have repeatedly seen them result in death. It may therefore be questioned whether it would not be better to keep the little patients under watch, and reserve operative interference until the tumor should show a tendency to increase. No doubt in some cases there would be here, as in other parts of the body, a shrinking, and even disappearance, of the growth; and should this not happen an operation could be undertaken upon the child at a more advanced age with greater hope of success. In the event of casual injury to the tumor prompt attention would in all probability avert serious trouble.

When an operation is determined upon, the child should be placed under the influence of chloroform, the base of the tumor transfixed with pins, and a ligature firmly tied behind them. If the ligature is to be relied upon, the pins are now removed and the strangulated tumor is left to fall off. Should the soft tissues yield under the ligature and bleeding ensue, hot water should be applied; if the oozing continues, a small cautery-iron at a black heat should be touched to the surface.

When the cautery is to be used the same course is pursued, but the ligature is not drawn so tight, and after the tumor has been thoroughly burned is removed; the pins are then taken out.

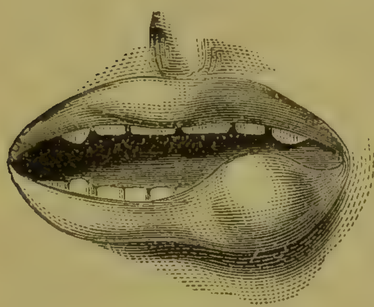
For excision, the pins and ligature are applied and the growth shaved away with a knife. Any vessels of sufficient size are then tied, and the

surface is touched with the cautery; the ligature is next taken off, and finally the pins are removed.

Instead of the pins and ligature, the tissues on either side of the growth may be seized, the whole thickness of the lip being embraced, with a pair of forceps with long parallel blades.

Mucous cysts are met with in the lips. They are true retention-cysts, and have the appearance shown in the cut (Fig. 223). I have never seen them except in adults, and they are annoying chiefly from their unsightliness. A seton will generally cause the loss of their contents and inflammation enough to bring about adhesion of the walls. Should this fail, free incision and swabbing out with strong tincture of iodine may be resorted to.

Fig. 223.



Mucous Labial Cyst.

Small *adenomata*, or hypertrophied glands, are sometimes found in the substance of the lips. They belong to adult life, and should be excised, as they may attain a troublesome size. They are distinguished from more dangerous growths by the absence of lancinating pain, and by the fact that they are deep in the substance of the lip. Moreover, they may be multiple.

Very rarely, *fatty* tumors, or lipomata, are seen in this region. They may be easily excised without fear of return.

Warty growths, abundant proliferations of epithelium, are not very uncommon in the lips. In children and young persons they are apt to be soft, and sometimes have a tuft-like appearance. In adults these formations are more commonly hard, and irregular in shape; and more so the later the period of life. When they have begun as small shot-like bodies under the mucous membrane of the lip, they are especially apt to mean serious mischief.

The soft warts met with in childhood may be destroyed by applications of fuming nitric acid, of glacial acetic acid, or of solution of subsulphate of iron. Strong carbolic acid sometimes dries them away effectually. Either of these remedies must be applied only to the wart itself, the skin or mucous membrane being carefully protected by vaseline or oil. A fine glass brush, very slightly charged, is the best thing to use for the purpose.

For the harder warts of adults excision is the only remedy, and should be promptly carried out. The maxim, that no warty tumor appearing on the face of a person beyond middle life should be permitted to remain, is of especial force in regard to the lips.

Epithelioma, or epithelial carcinoma, is of very frequent occurrence in the lips, affecting the lower one almost exclusively, except by extension. It begins as a little hard, shot-like body just under the mucous membrane, and gives no pain. Gradually it ceases to be movable, and a little crust gathers over it from time to time; then this becomes thicker, and is shed less easily, until it assumes a warty character, and occasionally bleeds a little. As the wart develops, the mass below it becomes larger and harder, involving the tissues around it, until the

whole thickness of the lip is increased, and the lump attracts attention. From time to time lancinating pains are felt in the mass, and these become more frequent and more severe. The patient now becomes alarmed, and seeks medical advice. Occasionally his physician vainly tries to destroy the growth by caustics of greater or less severity, but only succeeds in irritating the tumor, which grows more rapidly, ulcerates, and may assume the appearance and proportions shown in Fig. 224. The discharge is apt to be very offensive.

FIG. 224.

Epithelioma of Lip.

FIG. 225.

Line of Incision for Removal of Epithelioma of Lip.

The proper course to pursue in any such case is to freely excise the whole mass by a V-shaped incision (Fig. 225) through the entire thickness of the lip, carrying the knife through sound tissue only. I use the bevelled incision, and in one case in 1886 the healing was perfect, without scar, on the third day. The wound is closed by means of harelip pins, and antiseptic dressings are applied.

Unfortunately, the disease is very apt, sooner or later, to return. Yet years of comfort may be secured by early operation. In one case known to me the patient's life was prolonged fifteen years by successive removals of the recurring tumor: he was operated on four times, first with the knife, then twice with scissors, and lastly with the knife again, a plastic operation being required to fill up the gap left in the tissues.

FIG. 226.

Epithelioma of Lip at an Advanced Stage.

Left to itself, this disease advances steadily and extends to the upper lip: a large irregular mass of adventitious growth, with a cracked and ulcerated surface, from which flows a horribly offensive discharge, takes the place of the healthy tissues. Such a condition of things is shown in Fig. 226. The glands beneath the jaw

become involved, and the bone itself is attacked. The pain from the growth at this stage is excessive, and involves often the whole side of the face, running back to the ear. The general health suffers; sleep, except with the aid of anodynes, is impossible; solid food cannot be taken; and a more wretched state of existence can hardly be imagined.

The dotted line in the figure shows the incisions made for the removal of such a growth—an operation only to be recommended in exceptional cases where the glands of the neck have not yet become involved, and the general condition of system is still good. A very extensive plastic operation would be needed to fill in the great gap left by so extensive a removal of parts. In such a procedure it is very important to arrange the incisions so that the flaps can be brought together with the least possible degree of tension. Rapid and complete healing is one of the great points to be aimed at, since any portion of the sore which remains open is apt to become the seat of recurrence of the disease.

The relief afforded by these operations is often great, even if it is but temporary; and the respite given is in some cases much more prolonged than the surgeon would have ventured to promise or the patient to anticipate.

It would be difficult to overstate the misery of the final stages of this dreadful disease, as the victim is slowly worn out by agonizing pain, starvation, and want of sleep. Occasionally, it happens that his sufferings are mercifully cut short by hemorrhage, from the ulceration involving an artery; but usually the vessels are sealed up by adhesive inflammation and by outside pressure as the growth advances. Release is more frequently gained by the occurrence of blood-poisoning, taking the form either of ordinary septicæmia or of septic pneumonia.

Of the treatment of these cases little need be said, as it is summed up in anodynes, concentrated food, and antiseptic dressings. Morphia is the main reliance, but may be alternated or combined with the bromides, chloral, cannabis indica, etc. My own rule is always to push the remedy until the effect is produced. Enormous doses are sometimes taken, with relief to pain and with no bad after-consequences. The hypodermatic method may be used to great advantage if the stomach is disturbed by the internal administration of morphia.

As to the local applications, the sore should be syringed out or irrigated with a weak solution of permanganate of potash as often as may be convenient or necessary, and the same should be used as a mouth-wash and gargle. Solutions of carbolic acid, boric acid, chlorinated soda, chloride of zinc, or other astringent and antiseptic substances should be applied by means of lint or charpie as dressings in the intervals of the irrigations. I have not myself found cocaine to answer any good purpose in allaying the pain of cancer or other malignant disease, either in the mouth or elsewhere.

Operations on the Nerves.

Certain areas supplied by branches of the fifth pair of cranial nerves are occasionally the seat of intense pain, for the relief of which division of the nerve-trunks may be resorted to. This pain is sometimes

"neuralgic," there being no lesion discoverable as its cause; or it may be due to neuritis; or it may be merely a symptom of organic disease, such as cancer of the tongue.

Mere division of the nerve-fibres is, however, apt to fail of giving permanent relief: when possible, it is better to excise as large a segment of the trunk as can be isolated, and in some cases the doubling over of the peripheral portion upon itself has been done with success.

Nerve-stretching has not yet been fully tried in this region, but promises well from the results yielded by it elsewhere. The object of this procedure is to produce a temporary interruption of the transmission of impressions through the nerve-fibres, and to effect such a change in their nutrition as to lessen their sensitiveness or irritability. What is the precise nature of this change has not yet been shown; and indeed this method of treatment is still in a great degree empirical.

The *supraorbital* nerve may be exposed by an incision along the lower edge of the eyebrow, and a shorter one from its inner end upward on the forehead: the triangular flap thus made can be turned up so as to expose the branches of the nerve, which are collected by passing a blunt hook under them, pulled out, and cut off. Oblique incisions will leave hardly a perceptible scar, and with antiseptic precautions healing by first intention may be expected to occur.

The *infraorbital* nerves are not unfrequently the seat of neuralgia. Here division or stretching may be first tried, and on the failure of relief from this the trunk of the nerve may be excised—a much more serious and difficult procedure.

If the upper lip is turned out upward, an incision along the reflection of the mucous membrane from the bone to the lip may be made, and the tissues divided until the nerves are seen emerging from the infraorbital foramen; they can then be collected with a small blunt hook and divided with scissors, or caught with forceps and stretched.

To exsect the nerve-trunk, a flap is raised by making an incision from near the inner lower angle of the orbit downward and outward, then curving upward to near the outer lower angle of the orbit; the middle of this cut should be a full inch below the level of its beginning and end. Turning up this flap, the nerve will be seen emerging from the foramen. The bone is then bared from below upward, and the crown of a small trephine is applied just below the foramen, opening into the antrum. By careful chiselling the bridge of bone between the trephine-hole and the foramen is cut away, as well as the portion of the roof of the antrum which overlies the nerve. This latter, being thus exposed as far back as the posterior wall of the cavity, is pulled forward and divided with a pair of scissors curved on the flat, carried as far back as possible.

The *inferior maxillary* nerve divides into two branches, the lingual or gustatory and the inferior dental; these must be separately considered.

The *lingual* or *gustatory* nerve passes downward between the pterygoid muscles, over the edge of the superior constrictor muscle of the pharynx, to the side of the tongue, crossing the duct of Wharton. This nerve may be exposed in either one of several ways, the object of the opera-

tion having been to allay pain and check salivation in cancer of the tongue. The mouth is held widely open by a gag.

(1) It may be divided by a cut with a curved bistoury at the inner side of the jaw, from just below the last molar tooth to the angle, the knife being carried down to the bone.

(2) It may be exposed by an incision through the mucous membrane of the floor of the mouth, just back of the sublingual gland.

(3) The mucous membrane may be divided downward, inward, and backward, from the second molar tooth, about an inch; the nerve will be found in the wound.

(4) If the tongue be drawn out to one side, the lingual nerve on the other side can be readily felt as a cord under the mucous membrane. Section here would be easy, but the part is apt to be wholly changed by the presence of disease severe enough to call for surgical interference.

The *inferior dental* nerve passes, with the artery of the same name, along the inside of the ramus of the jaw to enter the dental foramen.

(1) It can be reached by an incision along the anterior edge of the ramus of the jaw; then, on dividing a few fibres of the internal pterygoid muscle and some connective tissue, it will be seen just outside of the stylo-maxillary ligament, between this and the bone.

(2) The ramus being exposed by an incision from without, the crown of a trephine is placed at the middle of its surface, and on removing the button of bone the nerve and artery will be seen through the trephine-hole, running from above downward. The nerve may be caught up with a blunt hook, pulled out, and a portion of it removed.

Other operations have been proposed and executed for the relief of these neuralgias, with the view of reaching and dealing with the deeper-seated portions of the fifth nerve. They are, however, of the greatest difficulty and gravity, and demand special study of the anatomy of the region. Moreover, the results likely to be attained are so doubtful that it may be questioned whether it is right to subject patients to the risk involved. I do not, therefore, deem it necessary to mention these procedures in detail.

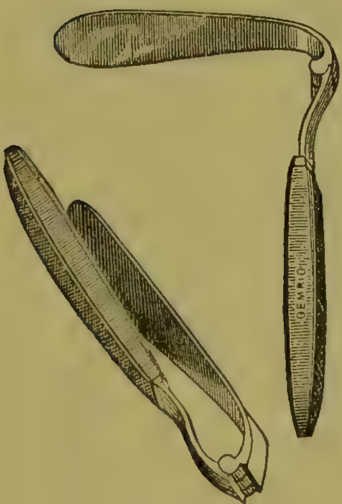
The *facial*, a motor nerve, has been cut down upon and stretched, or a portion of it exsected, in some cases of "tic" or muscular spasm in the parts supplied by it The paralysis ensuing is perhaps as bad as the previously existing disorder, but may not be more than temporary. The nerve is reached, if desired, by an incision about two inches long at the anterior border of the sterno-mastoid muscle, at its upper part. The parotid gland is held upward and forward, and the tissues are carefully divided until the nerve is seen as a white cord running forward and slightly downward.

Diseases of the Tonsils and Uvula.

The tonsils are extremely liable to inflammation. As in most of the other tissues and organs of the body, this may be acute or chronic, although the latter term is very often applied to a condition which would be more appropriately called hypertrophy, being merely an enlargement and overgrowth due to excessive vascular supply.

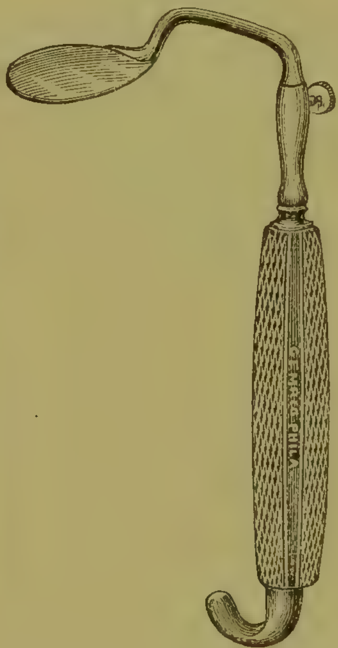
A few general remarks as to the examination of the tonsils and fauces may be given here. Many persons can exhibit the whole faucial region by widely opening the mouth, protruding the tongue, and saying "Ah" or "Ay." But in some the tongue is thick and unmanageable, and bulges up so as to conceal the parts; and in these, as often in children, some form of tongue-depressor must be used. Some surgeons use anything that may be at hand—a paper-cutter, a tablespoon-handle, or a wooden pencil. Perhaps these things effect the object well enough, but it should be a rule to use nothing that cannot be thoroughly cleansed afterward, and in his office at least the surgeon should always have a special instrument for such examinations. Fig. 227 shows a good form of tongue depressor in very general use, which can be folded up for convenience in carrying. Fig. 228 represents another kind, intended to be applied from the side; it may be reversed, so as to be used either

FIG. 227.



Tongue Depressor.

FIG. 228.



Another Form of Tongue Depressor.

FIG. 229.

Forehead Mirror.

from the right or left. By wearing the forehead-mirror (Fig. 229), the patient being placed with his back to the light, the surgeon has a full view of the parts without having to dodge the shadow of his own head. It is always better first to try whether the patient can control his own tongue and show the fauces without the tongue-depressor; if the use of this instrument is necessary, the blade should be placed well back over the tongue, and then brought straight downward, firmly but gently, so as to control it at once. A light pressure tickles the tongue and provokes cough or vomiting, and by pressure too far forward the organ is apt to be bruised or even cut; either of these things will perhaps make a child or a timid person unmanageable.

Medication of the tonsils may be effected by means of lozenges allowed to dissolve in the mouth; by gargles; by applying a brush or sponge charged with the remedy; by spraying with some form of atomizer; or by insufflation.

Acute tonsillitis is in most cases the result of "taking cold." It is very generally associated with catarrh of the naso-pharyngeal mucous membrane. Occasionally it is met with as a transient affection, which subsides altogether under appropriate treatment; more commonly some enlargement and thickening will be left, and the patient will become subject to such attacks, the glands remaining permanently swollen and hypertrophied.

At the onset of an attack of acute tonsillitis the patient will be chilly and complain of general aching and stiffness; he will have fever, "sore throat," difficulty in opening the mouth and in swallowing, with expectoration of tough mucus. The tongue is furred, and the breath foul and sickly.

On examination, one or both tonsils, and the mucous membrane covering the palatal half-arches and uvula, will be seen to be swollen and of a deep vivid red color. Both glands may be alike affected, but it is more common to see one considerably larger than the other; and occasionally the affection is wholly limited to one side. Often there is congestion of the mucous membrane and muciparous glands at the back of the pharynx. Here and there on the surface of the swollen gland will be seen yellowish-white patches, the tough and adherent secretion projecting from the orifices of the ducts and flattened out by pressure of the tongue, uvula, or opposite gland. These are often supposed by the ignorant to be ulcers or diphtheritic patches. Not unfrequently a swollen and tender lymphatic gland may be perceived below the angle of the jaw.

Sometimes the inflammation concentrates itself at one or more points in one tonsil, and abscess forms: such an occurrence will be marked by distinct chill, or at least by "creeps," and an increase of swelling at the affected point or points; the pain and tenderness are augmented, and the breathing becomes more embarrassed. Fluctuation may be felt with the tip of the finger or with the end of a strong probe or director. Great difficulty may be experienced in opening the mouth, making examination of the parts very unsatisfactory. Suffocation may sometimes seem to be threatened.

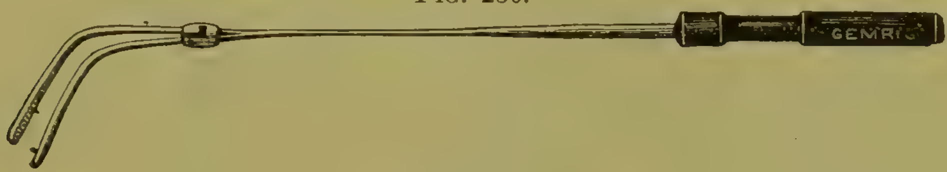
Acute inflammation of the tonsils may subside, leaving the parts merely congested, and they may sooner or later regain their normal state; but much more frequently it happens that resolution does not completely take place: the glands are left somewhat swollen and congested, and a fresh attack of the disorder is readily brought on by a fresh exposure to cold. As a result of repeated occurrences of this kind there ensues a state of irritative hypertrophy of the glands which may prove extremely obstinate. The swelling of the tissues prevents the closure of the orifices of the ducts, which are seen gaping, and gives a "honeycombed" appearance to the portion which projects into the fauces. This irregularity is sometimes enhanced by gaps left where there has been loss of substance by abscess.

The treatment of acute tonsillitis in its early stage is directed to reducing the fever and allaying local irritation. Some authors have recommended the administration of a mustard emetic as giving marked and immediate relief. A purgative dose of the mild chloride of mer-

cury will, however, be as effectual in unloading the portal circulation, and with it that of the alimentary canal, including the tonsil. If there is much fever, a hot foot-bath and ten grains of Dover's powder at bed-time, and liq. potassæ citratis or some similar febrifuge drink, may be given. All the food taken should be liquid, or at most semi-solid, and demulcent drinks should be allowed freely.

Of local applications a long list might be given. One of the best is a solution of nitrate of silver, from ten to thirty grains to the ounce of water, applied once daily by means of a sponge in a holder (Fig. 230)

FIG. 230.



Sponge-holder.

or with a camel's-hair pencil; care must be taken not to let any of the liquid flow down into the larynx, especially when the stronger solutions are used. Tincture of iodine has been employed in the same way. Tannin dissolved in glycerin answers well in some cases. Ether spray, thrown in with an atomizer, is sometimes very grateful. Gargles of hot water, of weak infusion of Cayenne pepper, of alum, of tincture of iodine and water, may be used to advantage.

In rare cases, when the swelling is very tense, scarification with a gum-lancet or with a curved bistoury wrapped to within a third of an inch of its point may be resorted to.

Abscesses of the tonsil will break of themselves, but much suffering may be saved by opening them as soon as fluctuation is perceived. The bleeding which ensues quickly reduces the swelling; but cases are on record in which it has been severe and even alarming.

Inflammation of the tonsils is a prominent feature in scarlet fever and in some rare cases of measles and smallpox. Here the system is under the influence of a specific poison, and the disorder may assume a typhoid type, when local gangrene is very apt to ensue. These cases are of the gravest character, and generally end fatally. Vigorous tonic and stimulant medication, with the assiduous use of antiseptics, must constitute the treatment.

Diphtheria is a subject belonging so entirely to the practice of medicine that it need not be discussed here. (For the method of treatment employed see p. 544 of this volume.)

Chronic tonsillitis scarcely demands separate consideration, but may be placed under the head of

Hypertrophy of the Tonsils.—This is an affection chiefly met with in the young and in those of a strumous constitution. It gives rise to a very disagreeable alteration in the voice, which becomes thick and muffled, with a somewhat nasal tone. The breathing is embarrassed, sometimes to such an extent as to alter the shape of the chest. Swallowing is interfered with, and nutrition may be seriously impaired. Partial deafness is apt to occur from thickening of the mucous membrane lining the Eustachian tube, and this, with the constantly open mouth,

gives a peculiarly unpleasant stupid expression to the face. During sleep, the mouth being kept widely open, loud snoring annoys even the patient himself, and the tongue becomes dry. The secretions from the tonsils become very offensive, and disturb the stomach when swallowed, or else must be continually hawked up and ejected. All these symptoms are materially aggravated whenever the patient takes cold.

Some advantage may be obtained in these cases by the frequent application of the solid stick of nitrate of silver, or by constant gargling with astringent solutions. But the most effective method of dealing with them consists in the abscission of a slice from each gland. By some surgeons this is done with a bistoury, the gland being drawn a little out and fixed with a pair of toothed forceps. Others have used the écraseur, a special form being devised for this purpose with a chain-carrier. The best instrument, however, is the guillotine, or tonsillotome, one form of which is shown in Fig. 231. Another, somewhat simpler, is represented in Fig. 232. A still simpler one, devised by Dr. Billings for supply in the U. S. Army medical outfits, is depicted in Fig. 233. In using either of these instruments the patient's mouth is widely opened, and the projecting part of the tonsil surrounded by the frame at the end of the shank; it is then secured by pushing forward the points or closing the forceps, when the blade is made to slide along, shaving off a slice of the gland. Both glands may be operated on at one sitting. This operation is so slightly painful that anæsthesia is scarcely necessary except in cases of refractory children. Only a thin slice need be removed. There is rarely any troublesome bleeding, although such an occurrence has been met with. Hot water, hot alum solution, or the subsulphate of iron might be employed to arrest it. In one recorded case a ligature was put upon an artery on the wounded surface, and torsion has recently been reported to have been employed with success in another. My own experience has been limited to the use of the tonsillotome, and I should hesitate to advise the use of the forceps and bistoury except in skilful hands.

The local treatment should be supplemented by the administration of a generous diet, with tonics. In many cases cod-liver oil would be plainly indicated.

Ulcers of the tonsils are very rarely seen, except after the separation of diphtheritic false membranes or in cases of secondary syphilis. In the latter they are the result of the breaking up of mucous patches, and the post-cervical lymphatic glands will be found enlarged and hard. Healing generally occurs readily, and may be hastened by mild astringents, one of the best of which will be found to be a weak solution of nitrate of silver. When there is an offensive discharge, solution of boric acid or of permanganate of potassa may be given as a mouth-wash.

Cancerous ulcers of the tonsils will be presently noticed.

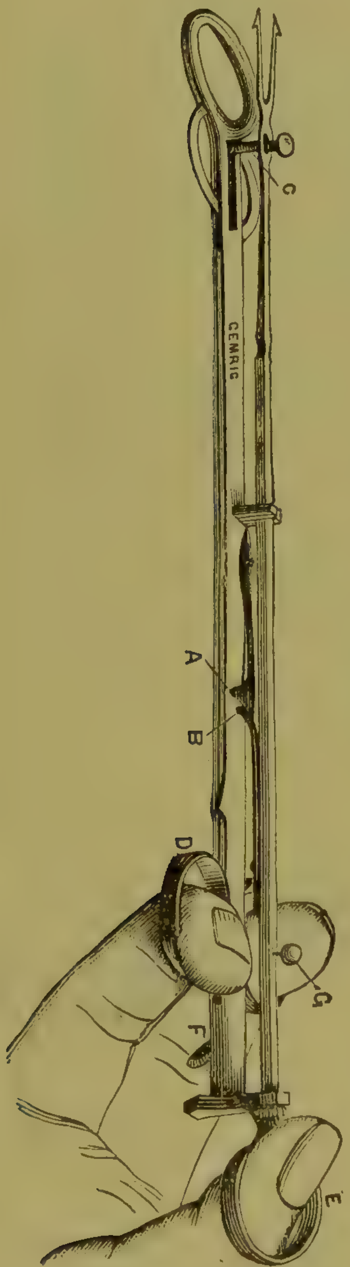
Foreign bodies, such as fishbones, are sometimes caught in the substance of the tonsils, and may give great annoyance. Extraction with suitable forceps is of course indicated.

Small calculi, very similar to those found in the salivary glands, have in rare instances been seen in the ducts of the tonsil. They act as foreign bodies, and should be carefully extracted.

Polypi of the tonsils have been described, but I venture to suggest that they may have been in reality partially detached portions of gland-tissue hanging by what seemed to be the pedicle of a new formation.

Cancer of the tonsils is always, I believe, of the carcinomatous type, and epithelioma. It has very seldom occurred as a primary affection, but has in almost all the few recorded cases been the result of extension

FIG. 231.



French Tonsillotome.

FIG. 232.

Another Form of Tonsillotome.

FIG. 233.

Billings's Tonsillotome.

of disease from the cheek or tongue. No treatment can be of any avail except removal, and the attempts of surgeons in this direction have not been attended with any such success as to encourage imitation. Complete removal, which alone would be of any avail, cannot be done with certainty from within the mouth; and the operation by an incision

behind the angle of the jaw is beset with difficulty and danger. But, apart from this, the return of the disease has been prompt in all the recorded cases of which the result was known; and it would seem to be sound surgery to abstain from operative measures.

In 1886, I admitted to my ward at the Pennsylvania Hospital a man forty years of age with ulcerated epithelioma of the fauces involving the right tonsil. No operation was deemed advisable. A few days later violent hemorrhage occurred, and the common carotid artery was tied by my resident surgeon, Dr. Penrose. The man did well for about forty-eight hours, when he became hemiplegic and died almost instantly.

The ulceration in these cases is really the only feature that admits of attempt at remedy, and what little we can do is simply in the way of allaying pain and preventing hemorrhage. The sores are ragged, irregular, with raised edges and a wide indurated base. They may be painted with solution of cocaine, or this may be injected into their substance. Tincture of aconite may be brushed over the raw spots, and if there is a tendency to bleed, the tincture of sesquichloride of iron may be applied in the same way.

Hemorrhage, when it occurs, may be perhaps checked by pressure with a small wad of lint damped with solution of subsulphate of iron or of gallic acid; or the carotid artery may be tied, as in the case above mentioned. But, if we dared say so, death in this way would be a merciful anodyne.

The *uvula* varies greatly in size and shape in different persons, being sometimes very short and thick, sometimes long and slender; it is moreover subject to constant change from contraction and relaxation of the muscles of the soft palate. I have seen it bifid: the peculiarity had produced no annoyance, and was only casually noticed by me.

FIG. 234.

Seiler's Uvula Scissors.

When the uvula becomes unduly elongated, it hangs down over the back part of the tongue, irritating it, and perhaps the epiglottis as well. A troublesome and harassing cough is thus provoked, with frequent ejections of mucus; nausea is also occasionally complained of.

Relief may be given by a very simple and almost painless operation. The mouth being widely opened, the tip of the uvula is caught with a pair of suitable forceps (the ordinary polypus-forceps answers very well) and drawn down, when the redundant part of the organ may be clipped off with scissors. Special instruments have been devised for this proce-

dure, of which the best is perhaps the one shown in Fig. 234. The catch with points is kept toward the tip of the uvula, and is intended not only to prevent retraction, but to secure the detached portion. Care should be taken not to cut off too much, not only because the effect on the voice might be unpleasant, but because there might be annoyance from bleeding in case of a very high division.

Tracheotomy.

Tracheotomy is an operation required when there is a mechanical obstruction to the passage of air through the larynx, or when a foreign body has entered the windpipe. The causes of such obstruction are various, the simplest being when, for example, a piece of meat or an artificial denture is drawn into the pharynx and jammed against the larynx so as to compress it. Lodgment of a foreign body, such as a bit of bone, within the larynx, œdema of the glottis, laryngitis with or without deposit of false membrane, laryngeal stenosis from contraction in the healing of syphilitic ulcers, tumors of the larynx, are among the most frequent of the conditions demanding this procedure. It is also resorted to, as elsewhere mentioned, as a preliminary to some other operations.

The urgency of the circumstances differs greatly in different cases: sometimes operation is called for instantly as the only means of preserving life, and the removal of the obstructing cause may be left for later consideration; sometimes attempts at relief in other ways may first be made.

Generally speaking, tracheotomy is easier in the cases of adults than in those of children; but it is impossible to judge beforehand, in any instance, of the difficulties which may present themselves. Sometimes very simple and readily performed, this procedure may in other cases demand the utmost nerve and skill.

The operation consists in the making of an artificial opening into the windpipe, through which breathing may be carried on. Its essential parts are—the exposure of the tube; the section of two or more rings; and the establishment of the opening thus made, so that air may have free access to the lungs.

Occasionally, when suffocation is imminent, the surgeon must at once open the trachea with a penknife or any instrument that may be at hand, and without waiting for anything in the way of preparation. Such cases are extremely rare, but they may occur, and life may be saved by prompt and bold action. The best plan is known as Durham's. The operator, standing on the patient's right side, grasps the front of the patient's neck with his left hand, sinking the thumb on one side of the trachea and the fingers on the other, and then bringing the thumb and fingers somewhat toward one another, so as to press the trachea forward, with the knife in his right hand he rapidly incises the tissues exactly in the median line with successive strokes, until the trachea is laid bare, when the blade is at once made to enter it, and turned in the wound so as to stretch it open. The after-treatment is as in other cases.

When the necessity for operation presents itself, but less urgently, the question occurs whether or not anæsthesia should be induced. Sometimes the patient, as in many cases of croup, is already in a state of unconsciousness from asphyxia; but if he is not it is much better to administer ether or chloroform, the latter being preferable, from the fact that it is less apt to cause pulmonary congestion, and that its use is not so often followed by vomiting. As little of the anæsthetic as possible should be given, and the time of its inhalation should not be needlessly prolonged.

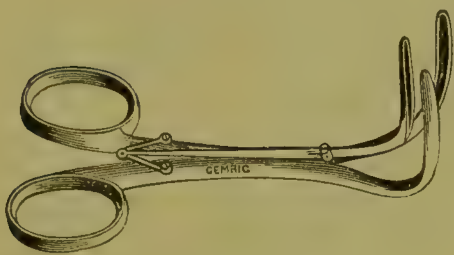
A good light is essential. The patient is laid on his back, with pillows or a large bottle rolled in a towel under the nape of the neck, so as to make the throat prominent. An incision is then made through the skin and superficial fascia from the lower edge of the thyroid cartilage downward about two inches, exactly in the median line. (In the very rare instances in which the trachea is deflected the incision must be made to follow it.) The tissues are now divided in successive layers, directly downward, to the same extent. This division may be made with the edge of the knife, each layer being raised by a grooved director passed under it, or the knife, a blunt instrument, or the finger-nail being used to scrape them through, the exact line being always rigidly maintained. Any arteries that spring are to be tied or twisted. If large veins present themselves, they may be held aside with a blunt hook, or tied above and below and cut between the ligatures. Sometimes there is a distinct space between the muscles lying along the front of the trachea, but sometimes the muscular tissue has to be cut through. Retractors may be employed to hold the tissues on either side out of the way of the operator, but those in charge of them must take great care to make exactly the same degree of tension on each, so that the median line shall not be missed. Should the isthmus of the thyroid body be encountered, it must be either drawn away with a blunt hook or tied on both sides and divided in the middle.

The trachea may be opened either above or below the isthmus of the thyroid body, the former operation being generally preferable on account of the fact that the trachea is more superficial above, and that there is less risk of uncontrollable or very troublesome bleeding.

The trachea being fairly exposed and all bleeding checked, for the higher opening the upper ring, next to the cricoid, is felt, and the point of a sharp bistoury is entered exactly in the median line just below it. When the lower opening is preferred, the ring just below the isthmus of the thyroid, or one at about that position, is felt with the finger. At either point it is a very good practice to catch the tube and steady it by inserting a small tenaculum or a little double hook in the wall of the tube exactly in the middle line, just above where the incision is to begin. Some operators prefer cutting from below upward, but it really makes very little difference. In the low operation this is perhaps safer on account of the left innominate vein. Air at once enters with a hissing sound, and as the opening is enlarged, air and mucus, often mixed with blood, will be expelled. A probe-pointed bistoury may now be used, and two or three rings, with the intervening tissues, divided downward in the median line.

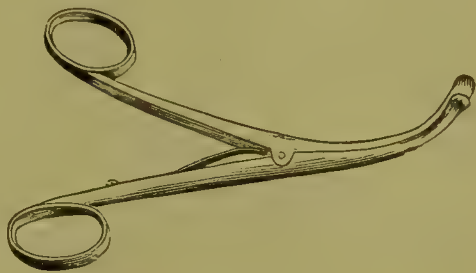
The surgeon now takes a pair of polypus-forceps, or the dilating forceps shown in Fig. 235, and introduces them, closed, into the orifice, which by separating the blades is dilated so as to admit a feather or a

Fig. 235.



Dilating Forceps.

Fig. 236.



Another Form.

small bit of sponge, either on a handle or securely held in a pair of bent forceps; this is passed upward and downward so as to swab out any mucus or blood-clots that may obstruct the entrance of air to the lungs.

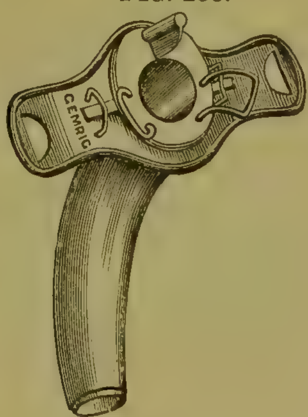
Generally, the relief thus afforded to the dyspnœa is immediate and decided. Children often fall asleep almost at once. The next object is to secure the advantage thus gained, and for this purpose several methods have been devised.

By some operators a small oval piece is cut out from the front wall of the trachea; and there is a good deal of experience in favor of this practice, or at least not adverse to it, but I cannot regard it as necessary, except perhaps in adults, in whom there may be some rigidity of the tissues. Others recommend the suturing of the edges of the wound in

Fig. 237.

Dilators for the Trachea.

Fig. 238.



Tracheotomy-Tube.

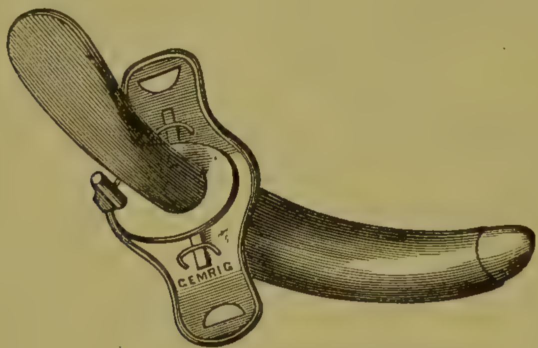
the trachea to the edges of the wound in the skin, the former being thus held apart, no tube being used. This method also has been found to answer well, but my own experience with it has been limited to one case, in which there was no opportunity to fairly test it. Under favorable circumstances and in the absence of the more usual appliances, I should be very ready to make further trial of it.

Dilators on the plan shown in Fig. 237 can be made of hair-pins in an emergency. The tapes are to be carried round the neck and tied.

Except that these would be easily displaced by movements of the patient, they seem likely to answer the purpose. In by far the greatest number of cases, however, use has been made of the tracheotomy-tube, the simplest form of which is shown in Fig. 238. This is commonly of silver or heavily silver-plated. It is double, an inner tube, easily removed for the purpose of cleansing, sliding within the outer one, which remains in place, being retained by means of tapes tied round the neck. These tapes ought always to be tied at the side of the neck, as the knot, if at the nape, annoys the child and makes him restless.

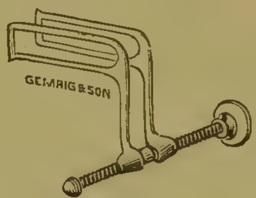
After a few days, when the wound has glazed, I think a single tube is better. Two should be provided, one being kept always clean and ready to be slipped in the moment the other is removed In order to facilitate the insertion, a guide with a blunt end may be used, as in Fig.

FIG. 239.



Tracheotomy-tube with Guide.

FIG. 240.



Golding Bird's Mechanical Dilator.

239. When only one tube, single or double, is employed, it is well to have the dilating forceps (Fig. 235) or Golding Bird's mechanical dilator (Fig. 240) at hand to open the orifice, and keep it so until the reintroduction has been effected.

The opening into the trachea having been made and its patency secured, the rest of the wound is to be closed with sutures, and a thin veil of gauze, hung over a narrow strip of adhesive plaster, adjusted so as to keep out dust.

Many suggestions have been made in regard to tracheotomy, and instruments devised for its rapid performance, but the description now given embraces all the essential features of the procedure. No tracheotomes or other appliances can possibly make up for awkwardness or timidity on the surgeon's part, and the simpler the apparatus used the better.

The after-treatment of these cases is fully as important as the mere operation. It consists in the care of the tube, the arrangements for a supply of properly warmed, dampened, and purified air, the feeding of the patient, the administration of suitable remedies for the condition which may have demanded interference, and the meeting of any emergencies which may arise. For all this the surgeon can give directions, but intelligent and watchful nursing is a matter of the utmost moment, and if possible it should be entrusted to some one trained or experienced in the care of this class of cases. A bungling operation, the case being well nursed, is more likely to be successful than one performed with the

most brilliant skill and the patient left in the charge of ignorant, awkward, or careless attendants.

The tube, it must be remembered, is almost always merely a temporary convenience, to be dispensed with as early as possible. While it is worn the utmost attention should be paid to keeping it clean and unobstructed.

A few words may be said in regard to some of the causes of failure in tracheotomy.

Blood is sometimes drawn into the trachea, and must be carefully withdrawn, if possible, by swabbing, by suction, or by turning the patient on his face and passing a feather in through the tube, so as to provoke an expulsive cough. Occasionally, the congested mucous membrane, when divided, bleeds freely into the windpipe. Pressure against the tube for a short time may check this.

By haste or awkwardness on the part of the operator the trachea has been entirely transfixed and the œsophagus wounded.

In the same way, the tube, instead of being properly placed, has been thrust into the tissues in front of the trachea.

The fascia has been nicked in several places, and air has thus found its way into the subcutaneous areolar tissue, causing emphysema.

Improperly-shaped tubes have irritated the lining membrane of the trachea, causing the formation of fungous granulations, and even abrading it. I saw in one case death ensue from the bleeding thus induced.

A not unfrequent cause of death after tracheotomy is pneumonia. This is sometimes the result of inhalation of air not properly warmed and purified, sometimes due to the extension of inflammation along the trachea, and sometimes from blood-poisoning.

Foreign Bodies in the Œsophagus.

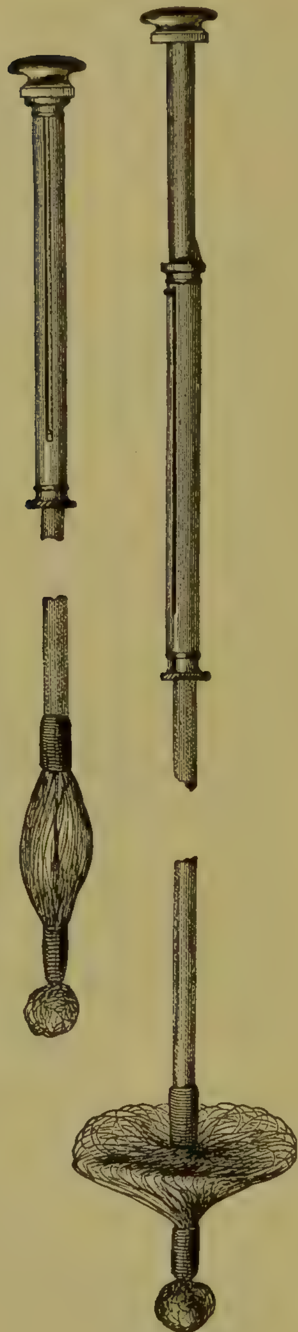
Occasionally foreign bodies, as plates of artificial teeth, are drawn into the gullet and held there. They then impede breathing, and of course swallowing, and if allowed to remain would give rise to inflammation and perhaps fatal mischief. Attempts should be made to grasp them with forceps, such as Bond's (Fig. 241), passed through the mouth; or the bristle probang (Fig. 242) may be pushed down, closed, past the foreign body, then expanded, so as to entangle it, and drawn up; or it may be caught by means of the swivel-probang (Fig. 243) and withdrawn.

Failing these efforts, an incision may be made along the anterior edge of the sterno-mastoid muscle, and the tissues divided inward until the œsophagus is reached, when an opening may be made and the foreign body removed through it. This incision should be exactly the same as for ligation of the common carotid artery, but the dissection is carried on inward, instead of backward through the sheath of that vessel. The œsophagus can be clearly made out between the trachea and the vertebral column. Often the foreign body bulges its wall, and affords a plain and unmistakable guide.

FIG. 241.

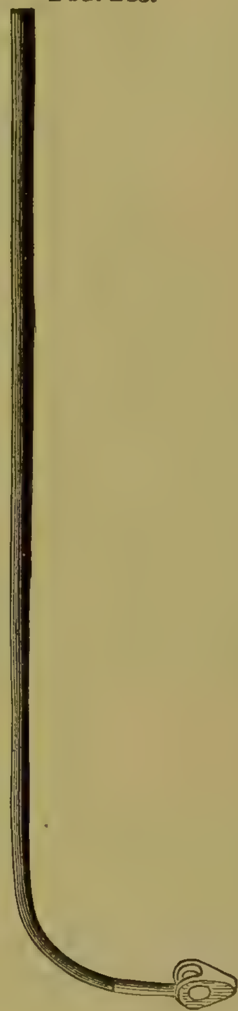
Bond's Œsophageal Forceps.

FIG. 242.



Bristle Probang.

FIG. 243.



Swivel Probang.

Any arteries divided must be tied; the great vessels will not be exposed at all. The wound generally heals without difficulty.

PART IV.

THE ERUPTION AND STRUCTURAL RELATIONS OF THE DECIDUOUS AND PERMANENT TEETH.

THE ERUPTION AND STRUCTURAL RELATIONS OF THE DECIDUOUS AND PERMANENT TEETH.

By C. N. PEIRCE, D. D. S.

THAT the evolution of human dentition has, in common with the dentition of other mammals, been from a simple and homogeneous type to a more complex and heterogeneous one, both as regards structure and form, is established beyond a doubt; and in this modification of tissue from the simple to the complex, and its arrangement, the *dietetic* habits have been accepted as important factors.

In considering intelligently the origin and peculiarities of mammalian teeth, and what might constitute a primitive mammalian dentition, it would seem quite necessary to have some definite knowledge of the teeth of the mammalian ancestry, and from these note the gradual change.

If, as has been suggested, we are limited in our choice to the Batrachia and Reptilia as mammalian progenitors, then to these animals must we look for our most primitive tooth-forms. These we find consisting of the cone-shaped ankylosed crowns, with the number large, uncertain, and frequent, and almost endless in succession.

Accepting the "placoid scale" or the "dermal denticle" as the structure from which all teeth were primarily derived, we have these teeth of the Batrachia and Reptilia as a step in advance, while in certain of the Reptilia a still further progress is made in the implantation of the teeth in distinct sockets, with the addition of a cingulum or an abortive cusp on the crown, and a tendency to bifurcation of the roots by flattening and longitudinal grooving.

From these primitive forms, with numbers and durability so varying, there is much room for modification before we reach the scalpriform incisors of the rodent, the trenchant sectorial tooth of the Carnivora, and the broad grinding molars of the Herbivora, or the less specialized and comparatively-fixed-in-form-and-number teeth of man. The uncertainty in the number and in the succession of the teeth of the Reptilia as compared with the two sets and definite numbers of the higher mammals has led to much conjecture regarding the origin of this definiteness, and to an effort to determine whether the deciduous or the permanent set is entitled to the credit of priority in its evolution; or, in those mammals which have but one set, whether it is the permanent or deciduous which has been lost.

Prof. Owen, in his effort to express concisely the conditions of replace-

ment, made use of the terms "diphyodont" and "monophyodont," and applied them as relative and interchangeable terms with "heterodont" and "homodont," believing that animals having two sets of teeth (diphyodont) had teeth differing in form and complexity in the several localities in the mouth (heterodont), while those having but one set (monophyodont) had teeth of similar form occupying the inferior and superior maxillæ (homodont); but to this rule many exceptions have been found.

Dr. Wortman,[1] in speaking of the relationship of the deciduous to the permanent set, asks: "Are they, the deciduous teeth, superadded embryonic structures similar to the amnion and allantois, which subserve a temporary purpose and disappear with approaching maturity, or are they to be homologized with the first set of teeth of the lower vertebrates?"

The very rudimentary conditions of the milk or deciduous teeth in some mammals is evidence of their transitional character; and if it is true that tissues most recently developed are frequently the first to be atrophied, it would seem that these were superadded structures. On the other hand, we must recognize the fact that the enamel-organs of these deciduous teeth arise *de novo* from certain portions of the lining membrane of the oral cavity, and that at a period in their progressive stage of development, by a process of budding, the enamel-organs of their permanent successors arise from the necks of the enamel-organs of the deciduous teeth, just as those of the temporary set do from the epithelial layer of the mouth. Another fact in this connection must also be noted—viz. the germs of the first permanent molars by their *de novo* origin stand physiologically in the same position as the more anterior deciduous teeth, and that the germs of the second permanent molars arise from those of the first, and the third from the second, just as do the germs of the permanent anterior teeth from the enamel-organs of their predecessors.

In noting the origin of the first permanent molar Dr. Wortman says:[2] "There is one thing upon which I would strongly insist, and that is, that the first true molar in the human dentition is a persistent milk molar."

In following the development of the deciduous teeth from the appearance of the epithelial eminence, the epithelial inflection, and the epithelial bands or enamel-organs, we recognize various progressive changes in the germinal tissues between the seventh and the seventeenth week. The modifications which are taking place during this period are in the embryonic structures for the development of the twenty temporary teeth, and from the fifteenth week for the development of what is recognized as the first permanent molar. From the seventeenth week these rudimentary structures for the temporary teeth begin to assume on their prospective coronal extremities the shapes of the future crown; and as this process is completed by the development of ameloblasts for the enamel and osteoblasts or dentoblasts for the dentine, the solidifying process commences by the deposition of the salts of lime in these previously prepared tissues. This process goes on, probably not without temporary interruption, until the crowns are completed, the incisors at about the fortieth week of fœtal life or at birth, the molars and cuspids when the infant is not more than six months of age.

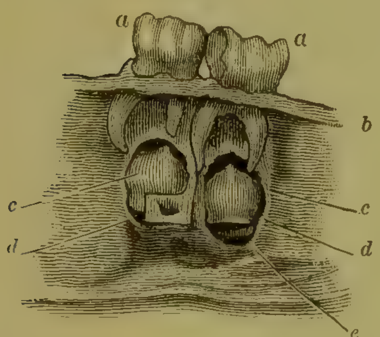
[1] See Vol. I. p. 498. [2] Vol. I. p. 500.

It is now that the crowns are advancing toward the mucous surface, facilitated by a threefold action—viz. the elongation of the dental pulp, the calcification of its surface to form the dentine of the root, and the adhesion of the dental sac or follicle to its solidified periphery: this last process places the cemental germ or matrix in position and stimulates it into functional activity, for until this period we have only had preparation for the development of two of the hard dental tissues (enamel and dentine); but with this the germinal development is completed, and growth henceforward progresses, modified only by accident or systemic and nutritional conditions.

At these periods, as will be illustrated by the subjoined figure, the deciduous tooth-germs with their partially calcified tissues are encased in bony crypts, which from about the twentieth week of intra-uterine life have been calcifying in the form of septa between the developing germs.

Enclosed first in a sac, the outer layer of which becomes ossified, the calcified tooth-crown with its primitive structures and elongating root is completely surrounded with a bony structure, each tooth in its own individual apartment, and occupying it so fully that room for growth can only be secured by the absorption of the superimposed tissue (Fig. 244).

FIG. 244.



The above figure, though representing a section of the lower jaw of a child about seven years of age, illustrates the development of the deciduous as well as the permanent teeth: *a*, *a*, deciduous molars; *b*, superior alveolar border; *c*, *c*, bicuspid crowns nearly completed in calcification; *d*, *d*, wall of crypt enclosing calcifying crown and formative tissues, the latter consisting of uncalcified dentine pulp and vascular sac (lining crypt and surrounding dentine and enamel-tissues), which serves as cemental germ or matrix; *e*, space occupied by dentine-pulp, the upper border of which, by infiltration of carbonate and phosphate of lime, is forming dentine.

FIG. 245.

Superior and Inferior Maxillary Bones, left side, of a six months' fœtus, the teeth removed from their alveolar crypts to display extent of calcification. All are accurately normal in size. *a*, superior maxillary, left side; *b*, inferior maxillary, left side; *c*, partially calcified deciduous teeth of upper jaw; *d*, partially calcified deciduous teeth of lower jaw.

The developing permanent bicuspids, *c*, *c*, and the uncalcified dentine pulp occupying space *e*, in Fig. 244, illustrate by their position in the close-fitting crypts, *d*, *d*, how impossible it is for the calcification of the roots to proceed uninterruptedly and without irritation, unless a corresponding absorption of superimposed tissue allows the crowns to be elevated as calcification progresses to the completion of the apical end of the root.

Fig. 245 is an exact representation in size of the superior and inferior maxillary bones, left side : the partially calcified teeth are removed therefrom. The specimens were from a six months' fœtus. The inferior mandible at this age shows an irregularly calcified groove, ossification of the septa being at this period of embryonic life in a frail and imperfect condition. The superior jaw has a similar appearance, with septa more decided, though the structure is not so readily displayed. The teeth, as seen removed from their encasements, represent the exact extent of calcification. The incisor crowns have attained about two-thirds their normal length, while the cuspids and molars have their cusps little more than formed.

Fig. 246.

Upper and Lower Jaw of Nine Months' Fœtus (two-thirds life size), exposing to view the alveoli and sockets or open crypts, from which the teeth on one side have been removed, exhibiting them from their palatine and lingual aspects (Tomes).

Fig. 246 represents the upper and lower jaws of a nine months' fœtus, the teeth having been removed on one side to show from their palatine and lingual surfaces the extent of their calcifiation at the period of birth.

Fig. 247 represents the superior and inferior maxillary bones, with the deciduous teeth in the average position, of a child seven months old. The superior centrals, both above and below, have the process absorbed from their labial surfaces, while the palatine and lingual surfaces are still covered by a border of the alveolar process kept prominent by the crypts which contain the germs and partially calcified crowns of the permanent successors.

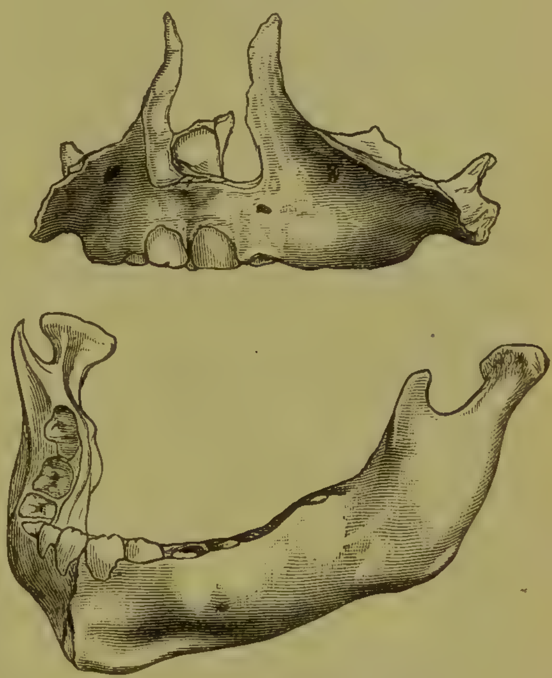
The absorption of the superimposed tissue from the advancing crown, and the elongation or growth of the root by an increase in the pulpy mass or formative tissue and its calcification, are the progressive developmental processes which we term "eruption of the teeth." While we shall not now discuss the propriety of the term used to express this physiological action, it is a pertinent inquiry whether "eruption" is an appropriate name for the process under consideration.

The force by which the teeth are propelled toward and through the mucous surface into position is thought by many to be something in addition to that indicated above as the result of normal growth. However this may be, there are occasional aberrant or abnormal results which it will not explain—viz. teeth erupted at birth or a few weeks after,

which teeth are not further developed than normal, yet have their crowns exposed as fully as if calcification were complete, such teeth being without further attachment with the subjacent tissue than the adaptation of the gum to their necks, while the uncalcified pulp is in juxtaposition with the base of the crown or of the abortive root, as the latter may have been more or less developed.

Such premature eruptions are usually found in children suffering from improper nutrition or other abnormal systemic conditions, and are independent of the force resulting from normal growth. The question at once arises whether such premature presentation of the tooth-crown is not wholly due to an absorption or wasting of the superimposed tissue, rather than to the elevation of the crown, which could not well take place without growth of root, unless it were from the contraction or an expulsive effort of the tooth-follicle.

Fig. 247.



Jaws of a Seven Months' Child. The incisors in both maxillæ are being erupted by the absorption of the gum from their cutting edges and the elongation of the roots by calcification (Tomes).

Charles S. Tomes, in his *Dental Anatomy*, p. 191, in speaking of this elevation of the tooth-crown, says: "Very strong objections have been brought forward, clearly proving that this cause (elongation of the root) is quite inadequate to explain all that may be observed. In the first place, teeth with very stunted roots, which may be practically said to have no root, are often erupted. Again, a tooth may have the whole length of its roots completed, and yet remain buried in the jaw through half a person's life, and then late in life be erupted. Moreover, when a healthy normal tooth is being erupted, the distance travelled by its crown materially exceeds the amount of addition to the length of its roots which has gone on during the same time."

A further illustration from the same author is given from *Comparative Anatomy:* "The tooth of a crocodile moves upward, tooth-pulp and all, obviously impelled by something different from mere elongation; and my own researches upon the development and succession of reptilian teeth clearly show that a force quite independent of increase in their length shifts the position of and erupts successive teeth. But what the exact nature of the impulse may be is an unsolved riddle, the explanations which I have read being, to my mind, less satisfying than the admission that we do not know."

Before leaving this interesting branch of the subject it is well to consider what are termed impacted teeth—*i. e.* teeth whose elevating or eruptive tendencies have been restricted or entirely obstructed from any

cause, whether it be unabsorbed bone or indurated gum-tissue. When the root completes its development under such unfavorable conditions, it is usually stunted or curved (more frequently the latter) in the direction where the surrounding tissue yields most readily. Hence the curvature of the roots is invariably posteriorly, or toward the ramus or tuberosity, as the tooth may be located in the superior or inferior maxilla.

Teeth in a horizontal position or inverted, as sometimes occurs, are subject to the same law of progress or projection—that is, in the line of the least resistance. All such teeth, when once fully formed without being erupted, make very slow progress toward the mucous surface except when adjacent or overlying teeth are extracted; then the necessary absorption of their alveoli exposes to view the previously imbedded teeth. There is a mechanical force, however, acting on all such teeth, tending to bring them to the surface, the same as on an unantagonized tooth, inducing its elongation or protrusion from the socket. The repeated closing of the jaws must exert, to a large extent, this mechanical force, just as the bung in a barrel is elevated by a blow being struck upon the stave on either side of it.

To return to the normal eruptive condition: From six to eight months after birth the bony crypts, which have scarcely completed the protective cell for the partially calcified tooth-germs and follicle, begin to be absorbed. This process goes on with considerable activity until the labial or outer wall of alveoli is removed; this takes place in advance of that covering the cutting edges. The temporary teeth are not all in the same progressive stage of development; hence we find that while some of the anterior teeth are being freed from their bony encasement, the posterior ones are still retained within their crypts, or it may be that some of them are but perfecting their enclosures.

Fig. 247 illustrates, in the absorption of the process from the incisor crowns, the average child at seven months of age. The labial surfaces and cutting edges are free from the bony covering, while the lingual and palatine are yet protected by the spongy bone which forms part of the crypt of the permanent successor. As soon as these crowns have freed themselves from their bony surroundings and have perforated the superimposed gum, the alveolus rapidly develops around the necks of the teeth and the elongated roots, the depth of the anterior part of the jaw increasing rapidly by this process; and as the molars are erupted, a similar condition in the posterior part of the jaw is concomitant with the elongation and elevation of the rami. Charles S. Tomes says (p. 192, *Dental Anatomy*): "The front teeth are erupted first, and the jaw deepens first in front; later on, the back teeth come up and the jaw is deepened posteriorly; meanwhile, the elongation of the rami has been going on slowly, but without interruption. Thus is brought about a condition of parts allowing of the whole series of teeth coming into their proper mutual antagonism."

It is very evident that the eruption of the teeth is not a continuous process, but that they have periods of growth and of rest, not only of the individual teeth, but of the teeth as a whole as they are developed

in groups or pairs, these periods of rest and growth being modified or intensified by the conditions controlling the function of nutrition.

While, as a rule, the inferior centrals are erupted first, there are so many cases where the superiors make their prior appearance that the exception must be noted. In the following text and table let it be understood that it is only intended to represent the periods of eruption of the deciduous teeth of the average child, giving a range of two or three months for the several groups or pairs, the writer believing that this will cover the large majority of cases.

The deviations from this "time," as just stated, may be earlier by three or four months, or later by the same period. So universally is the premature development associated with abnormal systemic conditions that it may be stated, with little danger of contradiction, that where the teeth are in process of eruption from the first to the fourth month the infant is suffering from either deficiency in quantity of blood or deficiency in some important constituents of the blood (anæmia). On the other hand, a delay in the eruption from the tenth to the thirteenth month as frequently finds the subject vigorous in body, with the nutritional condition representing all that this implies. The lateral incisors are usually from one to two months later than the centrals, and, reversing the order of the centrals, the superior laterals invariably precede the inferior. The first molars next in order have their cusps uncovered by the absorption of the gum from four to six months subsequent to the appearance of the laterals, there being no regularity in the priority of their eruption in one jaw over the other.

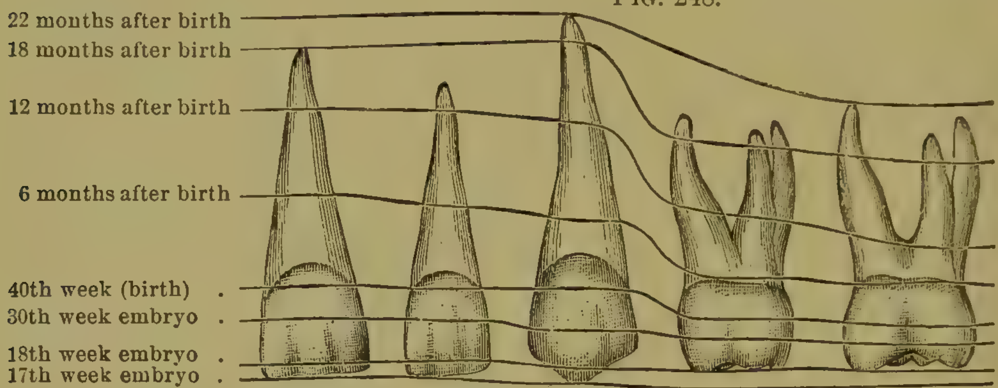
The cuspids or canines, following with about the same intermission, make their appearance between the lateral incisors and first molars; their progress is remarkably slow, and sometimes their eruption is delayed until after the appearance of the second molars. Various reasons have been ascribed for this delay. Trousseau thinks it is due to the greater length of their roots, but the probability is that, coming between teeth already in place, they have a denser and thicker tissue to penetrate. A longer time is required for the removal of this tissue and for the completion of the root, which latter process must be reckoned as one of the factors in bringing the crown into place. The experience of the writer has been that the eruption of these cuspids or canines, occurring during the months of July, August, and September, invariably produces or induces greater systemic disturbance than either of the other groups would under similar circumstances.

The eruption of the second molars usually follows close upon that of the cuspids, probably not more than one or two months intervening. With these the deciduous or temporary dentition is completed during the first two years of life, and sometimes this age is not reached by two months. A delay in the beginning of the eruptive process is not necessarily followed by a corresponding delay in its completion. The writer has been familiar with several families where no teeth were erupted before the eleventh or twelfth month, and yet the process was completed by the twentieth month and without unusual systemic disturbances.

At the sixteenth week of fœtal life the follicle which encloses within

its folds the enamel and dentine organs or germs of the future tooth is closed, and the epithelial band, which has thus far served to hold these germs in connection with the epithelium of the surface, is broken, and the prospective tooth-germs are in what may be called the second stage, or saccular condition. Quickly following this, lime salts are deposited upon the surfaces of these two organs, and a cap of dentine and a layer of solidified enamel-cells represent the shape and density of these two dental tissues. From the first appearance of these layers of solidified

FIG. 248.



Calcification of the Deciduous Teeth.

structures a process has begun, which, when carried to its normal completion, must result in a dental armature completely occupying the alveolar ridges of a two-year-old child; and from the beginning of this process we shall, for convenience, date the growth of the hard dental tissues, following them in the subjoined table from the commencement of calcification to their completion and arrangement in the dental arches, as follows:

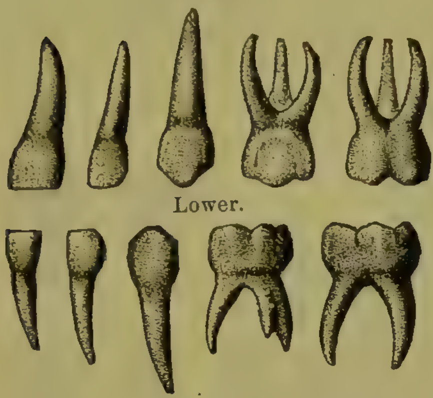
17th week of embryonic life, enamel and dentine of central and lateral incisors begin calcification.
18th week of embryonic life, enamel and dentine of molars and cuspids begin calcification.
20th week, calcification of crypts which encase enamel and dentine-germs begins.
40th week, or at birth, calcification of incisor crowns quite complete and roots begin to calcify.
3 months after birth, cuspid and molar crowns complete and roots begin to calcify.
6 to 8 months, central incisors erupted.
7 to 9 months, lateral incisors erupted.
14 to 16 months, first molars erupted.
17 to 18 months, cuspids or canines erupted.
18 to 24 months, second molars erupted. Temporary dentition complete.

While the above table represents the average eruption of the deciduous teeth, there are many exceptions representing tooth-eruption at earlier and later dates. As above stated, the earlier are usually in infants less vigorous in constitution than normal, waste exceeding supply, while the later periods are most frequently confined to those of good recuperative power and other favorable systemic conditions.

At the time of the eruption of the deciduous or temporary teeth the apical end of the root or roots is not necessarily completed in its calcification, and oftentimes some months elapse after the tooth has taken its

FIG. 249.

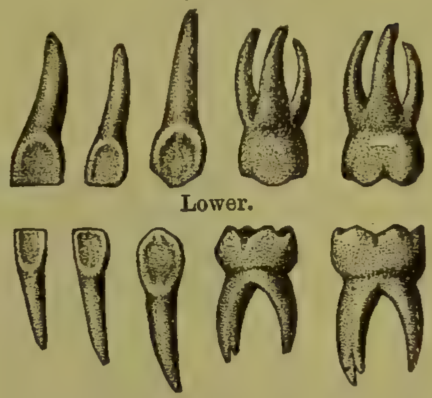
Left Upper.



Deciduous Teeth, left side, upper and lower: labial view of centrals, laterals, and cuspids; buccal view of first and second molars, all slightly convex on the crown, the former single-rooted, the latter, superior, three-rooted, two buccal and one palatine; inferior, two-rooted, anterior and posterior; with tendency to bifurcation, shown by longitudinal grooving, which is often sufficiently deep to divide the pulp-cavity. Roots are in a completely calcified condition, as seen previous to the commencement of absorption.

FIG. 250.

Right Upper.



Deciduous Teeth, right side, upper and lower: view of palatine surface of superior and of lingual surface of inferior, the centrals, laterals, and cuspids slightly concave on this inner aspect, giving the crowns a wedge shape viewed from their lateral sides; the molars markedly convex on their crowns, the convexity terminating on the necks with a decided constriction.

place in the arch before the foramen in the end of the root is reduced to its normal size.

The arrangement of the teeth in two parabolic curves, the superior describing a larger segment of a circle than the inferior, with the exter-

FIG. 251.

Upper. Lower.

Lateral or Side View of Deciduous Teeth, their largest antero-posterior diameter well shown to be on coronal side of neck, the relative size of buccal and lingual cusps also displayed, as well as the wedge shape of the incisor and cuspid crowns.

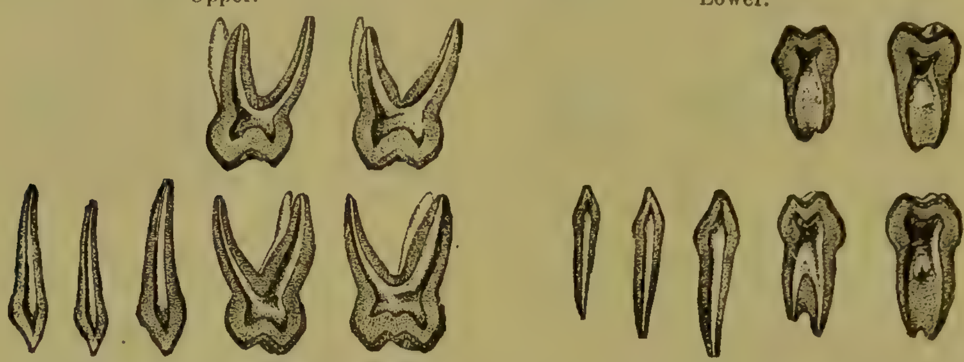
FIG. 252.

Upper. Lower.

Deciduous Teeth, with vertical division through the antero-posterior diameter of the pulp-chamber, showing relative size and situation of the pulp within the tooth, and its diameter varying with the diameter of the tooth-tissue, as well as the cornu or horns of the pulp extending into the coronal cusps.

nal cusps of molars and the cutting edges of the anterior teeth closing a little external to the inferior, is a normal position seldom deviated from in the deciduous or temporary set. The teeth when first perfected are also equal in height, so that resting the antagonizing surfaces upon

Fig. 253.

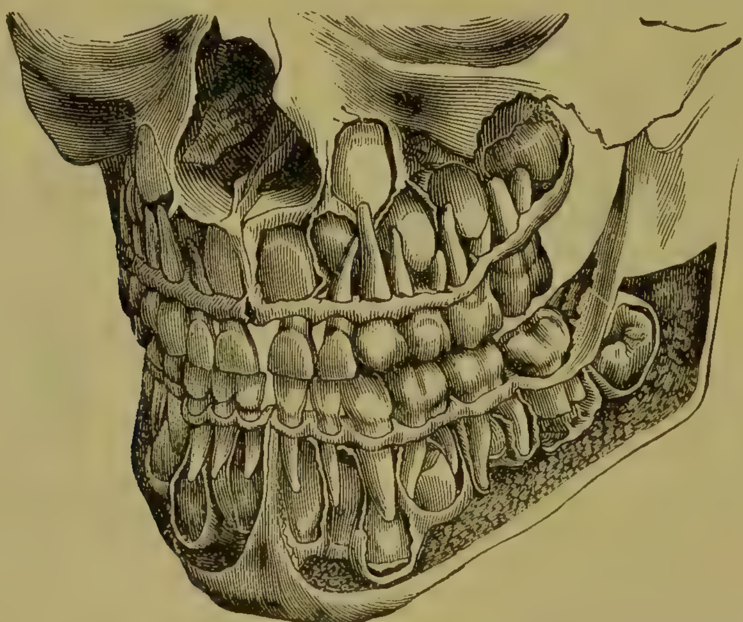


Deciduous Teeth, with vertical division through the lateral diameter of the pulp-chamber, showing the projection of the pulp into the wedge-shaped incisor and cuspid crowns, and its relative size in the palatine and buccal roots of superior molars, and the division of the pulp-chamber by the longitudinal grooving of the inferior molars.

a plane, all would bear equally upon it; they also stand side by side in close juxtaposition, without diastema or spaces between them.

This last is a peculiarity of temporary duration, however, and is not usually observable after the fourth or fifth year. The crypts containing the partially-developed permanent teeth which are to succeed the decid-

Fig. 254.

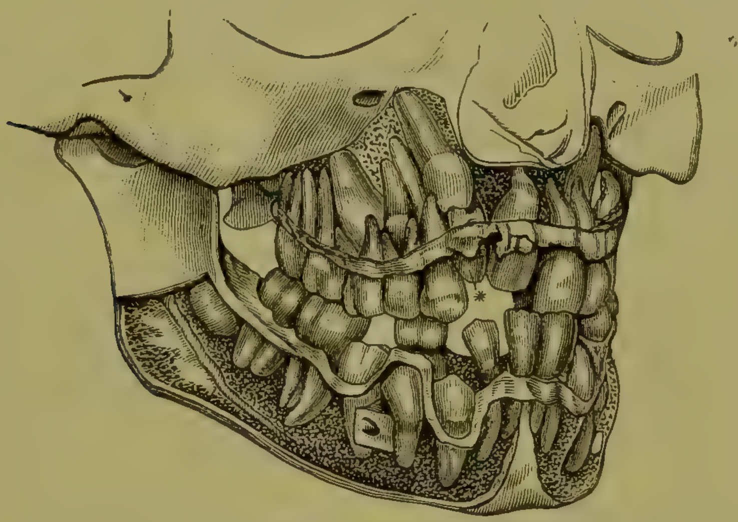


View of the Upper Jaw of a Child aged about 6½ years. The anterior teeth are slightly separated by the partially-developed permanent teeth, lying behind or posterior to them, pushing forward to occupy a more anterior position. The equal height which the crowns of the deciduous originally occupied is also being disturbed by the advancing permanent teeth.

uous ones, behind or posterior to which they lie, are gradually pushing forward and occupying a more anterior position; and in this developing process the temporary teeth may be observed to be slightly separated, as in Fig. 254. They are also, from the same cause, elevated from

that uniform height which marks the early normal development, as seen in Fig. 255.

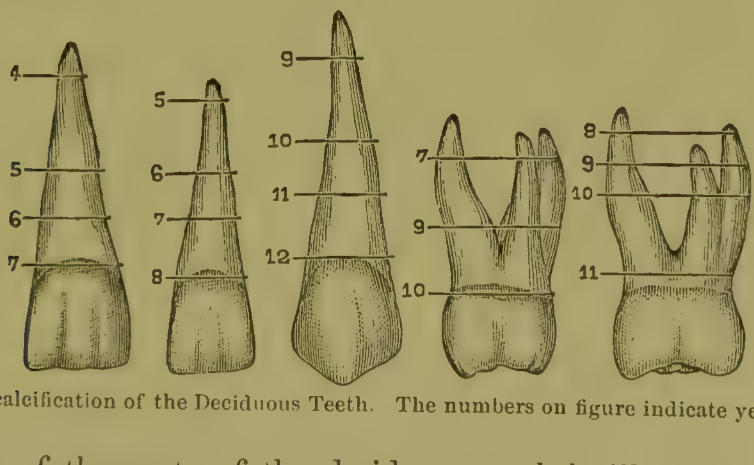
FIG. 255.



Represents the jaws and teeth of a child about fourteen years of age. The irregular position of the teeth and the close adaptation of the alveolar border to their necks, without reference to the position of the crown, illustrate very fully the entire dependence of the alveoli upon the teeth: the right inferior first molar is seen in the figure to be elevated by the advancing first bicuspid to the same level as the permanent incisors, yet the alveolar border protects its neck, while the adjoining permanent cuspid, occupying a position much below it, carries the same border to its level (Tomes).

The roots, which we have seen become perfected and present cone-shaped apical ends with minimum-sized foramina, are of short duration, for scarcely more than a year elapses after their completion before preparation is made for a retrograde metamorphosis, which results in the gradual dissolution of the lime salts and a return of the organic element in the root to its embryonal condition. The decalcification or

FIG. 256.



Decalcification of the Deciduous Teeth. The numbers on figure indicate years.

absorption of the roots of the deciduous teeth is illustrated as far as possible by Fig. 256; and in this effort to tabulate this interesting and obscure physiological process it is difficult to do more than approximate the time at which it takes place. The period at which it begins, as well as the several progressive points indicated by the figures expressing years of age, though probably not accurate to the month, are yet suf-

ficiently correct to warn the dentist of the need of great care in the application of arsenic for the devitalization of the pulp and in the subsequent treatment of the pulp-chamber and root-canal. This process, beginning first in the roots of the incisors, progresses gradually, when it is to be completely and normally accomplished, from the extreme or apical end of the root toward the crown, occupying about three years in its dissolution; and usually releases the crown of the deciduous incisor between the seventh and eighth years, the absorption of the centrals' roots ordinarily preceding those of the lateral by some months. The absorption of the roots of the first deciduous molars may be placed a year later than those of the lateral incisors, beginning about the middle or close of the sixth year, and terminating with the removal of the first deciduous molars, about the tenth year, the second molars following usually some months or a year later. The cuspids, not infrequently the last of the deciduous teeth to be shed, have their period of absorption extending from the eighth to the twelfth year. While these periods correspond with the absorption and removal of the teeth in the average mouth, so variable are they in different families that many wide differentiations may be found.

Charles S. Tomes,[1] in speaking of root-absorption, says: "It was a matter first accurately investigated by my father. The root, at or near to its end, becomes excavated by shallow cup-shaped depressions; these deepen, coalesce, and thus gradually the whole is eaten away. Although absorption usually commences on that side of the root which is nearest to the successional tooth, it by no means invariably does so; it may be, and often is, attacked on the opposite side, and in many places at once.

"The cementum is usually attacked first, but eventually dentine, and even enamel, comes to be scooped out and removed by an extension of the process. That part of the dentine, however, which immediately surrounds the pulp appears to have more power of resistance than any other part of the tooth, and thus often persists for a time as a sort of hollow column."

That the absorption of the temporary teeth is absolutely independent of pressure is evidently the conviction of Mr. C. S. Tomes; in which the writer fully concurs, though he would take issue with the statement that a successful absorption may begin on other localities than the apical end of the root, and go on to completion.

The absorptive process, though a physiological one, is certainly somewhat obscure, and in contradistinction to the evolution of the tooth may be termed its dissolution.

The evidence of its being the result of a physiological action is in the fact that it matters not from how many centres it has commenced, it must, to be successful, involve in its early stages the root-canal and pulp therein, the latter maintaining vitality until completion, as the very moment vitality of the pulp ceases, that instant this retrograde metamorphosis designated "physiological absorption" terminates.

What induces this molecular dissolution it is difficult to state, though the several conditions which are always present and essential are readily

[1] *Dental Anatomy*, p. 195.

recognized, but the part they play is not easily ascertained. The place of its commencement, at the end of the root, the retention of pulp-vitality, and the presence of a vascular papilla in close proximity to the absorbing surface, with the fact that the surface of this papilla is rich in giant-cells termed "osteoclasts," are evidently essential accompaniments, and the absence of any one of them would certainly militate against the completion of the process.

The statement that the presence and pressure of the permanent tooth are essential cannot be sustained, as frequently the decalcification of the deciduous tooth is successfully accomplished in the absence of its successor. Again, we often find the permanent tooth impacted against or within the bifurcated roots of the deciduous molar, or pressing down by the side of its single-rooted predecessor, both being more or less displaced by the persistence of the unabsorbed deciduous roots. That the organ has served its purpose, and the nourishment which had previously been appropriated by it is diverted or relegated to its successor, are probably important factors contributing to the success of this interesting physiological process.

This demonstration of dissolution is not alone confined to the roots of the teeth. The rami of the inferior maxillary give evidence of a similar phenomenon by absorption from their anterior borders, with corresponding growth of the interstitial tissue, giving development and prominence to their posterior lines.

There are also bone-cased cavities and canals increasing in diameter and capacity by absorption from within and addition to the surrounding walls. These, we conclude, are the results of similar physiological efforts.

In considering the absorption of the roots of deciduous teeth we must not overlook the difference between what has just been designated a physiological process, dependent upon the vitality of the absorbing structures and its contiguous tissues, and the pathological one, which is the result of a suppurative process following the devitalization of some of the same structures—a process which is well illustrated in Fig. 257.

In the former case, as above stated, when successful the absorption begins at the apical end of the root, and removes the tissue by a gradual encroachment toward the crown, the interior of the root yielding to the solvent most readily, so that there is constantly maintained an inverted cup-shaped cavity into which protrudes the above-described vascular papilla, the active organ in this retrograde metamorphosis. On the other hand, when the pulp is devitalized and an alveolar abscess is established at the apex of the root, a very different condition is presented. Through the influence of the pus in which the root is constantly bathed it presents a peculiar worm-eaten appearance, the shallow grooves oftentimes encircling the root, and presenting several more or less broken, ring-like excavations, varying in depth and wholly unlike in progress and completeness of result that which we have described as being physiological and occurring in the vital root, the devitalized root never being wholly removed by the pathological process.

We have thus described the influence of what we have been pleased

to designate normal and abnormal or physiological and pathological absorption upon the roots of the deciduous teeth.

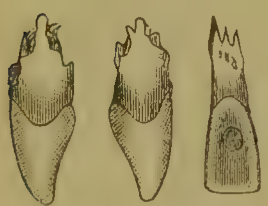
These same absorptive processes have not been without their influences upon the permanent teeth; but when acting upon these structures much more frequently does it assume an abnormal type: in the large majority of cases disease has been the exciting cause, hence root-disintegration of the permanent tooth would in such cases be pathological. So dissimilar are the two processes, both as regards the progress and the appearance they present, that one would hardly hesitate for a moment in designating that process affecting the permanent teeth as pathological in contradistinction to the one removing the deciduous teeth, which we have styled physiological.

The exciting causes which stimulate in the permanent teeth the abnormality under consideration may be classed as largely mechanical—*i. e.* injuries, such as partial or complete dislodgment and replacement, malposition of the affected or the adjoining tooth, and a crowded condition of the arch.

It is rarely—indeed, it might be safe to say it is never—possible for a tooth to be dislodged from its socket and replaced, or for another tooth to be inserted in its stead, without there being a persistent effort to reduce the bordering-line of one or both tissues which have been disturbed to their embryonal condition. If this effort is properly sustained by systemic nutritional wealth, the harmonious readjustment of the tissues to each other does not result in much sacrifice of structure; but with feeble recuperative power, deficiency in quality and quantity of pabulum appropriated, and hence in quality and quantity of blood, then permanent deficiency of tissue must result. Of all the teeth inserted or reinserted with which the writer has been familiar, a final loss of the tooth by root-absorption could be traced to systemic peculiarities and defective manipulation as important factors inducing the result: that the most exquisite technical skill cannot ensure success without regard to temperamental and nutritional qualities goes without saying.

The following figures give unmistakable evidence of absorption very unlike that noticed in deciduous roots, where the dentine is the tissue most rapidly removed. These specimens and others in the writer's possession fully illustrate the destruction of the cementum and the maintenance of irregularly cone-shaped masses representing what is left of the roots.

Fig. 257.



Malposition of the tooth whose root is affected or of the adjoining tooth may induce irritation of the pericemental membrane either by malocclusion or by pressure, and hence stimulate absorption of the cementum, while a crowded condition of the arch or of a single tooth may produce the same result.

Coleman (by Stellwagen, p. 253) says: "In attempting to account for the various phenomena met with in absorption of the teeth, the difficulties have, we think, been augmented by our looking for special organs capable of effecting the process. Altered conditions in their surroundings have no doubt the greatest influence in effecting either

their hypertrophy or their atrophy; an undue determination of blood may stimulate the osteoblastic layer or the cemental portion of the alveolo-dental membrane, and so produce hypertrophy of the cementum. On the other hand, stimulation of the osteoblastic layer of the alveolar portion of the same membrane may induce growth of the alveolus inward. The result of this latter may be pressure upon the osteoblastic layer of the cemental portion of the membrane, and in consequence induce the osteoblasts to take on an absorptive action—in fact, to become osteoclasts—and effect more or less the destruction of the fangs of the teeth. The absorption of bone brought about by the pressure of an aneurism is no doubt effected by the same agency."

Eruption of Permanent Teeth.

In writing of and tabulating the eruption of the permanent teeth we shall pursue the same plan adopted with the deciduous set, believing that it is a matter of considerable clinical interest to recognize the early date at which these teeth begin their dentification, so that it may be easily recalled when teeth are met with in which calcification is very imperfectly performed.

By referring to Dr. W. A. Sudduth's admirable article in Vol. I. it will be seen that as early as the fifteenth week of embryonic life preparation is made for the development of the four first permanent molars; and following close upon these, in the sixteenth week, is the inflection giving rise to the enamel-organ for the twenty anterior permanent, the successors to the twenty deciduous teeth; and from this period until the birth of the infant the germs for twenty-four of the permanent teeth are passing through their several progressive stages preparatory to receiving the salts of lime. At birth, then, the child has not only the twenty deciduous teeth largely advanced toward calcification, but has the germs of twenty-four permanent teeth, in twelve of which calcification commences the first year. The germ of the second permanent molar makes its appearance the third month, and that of the third molar (wisdom tooth) the third year after birth.

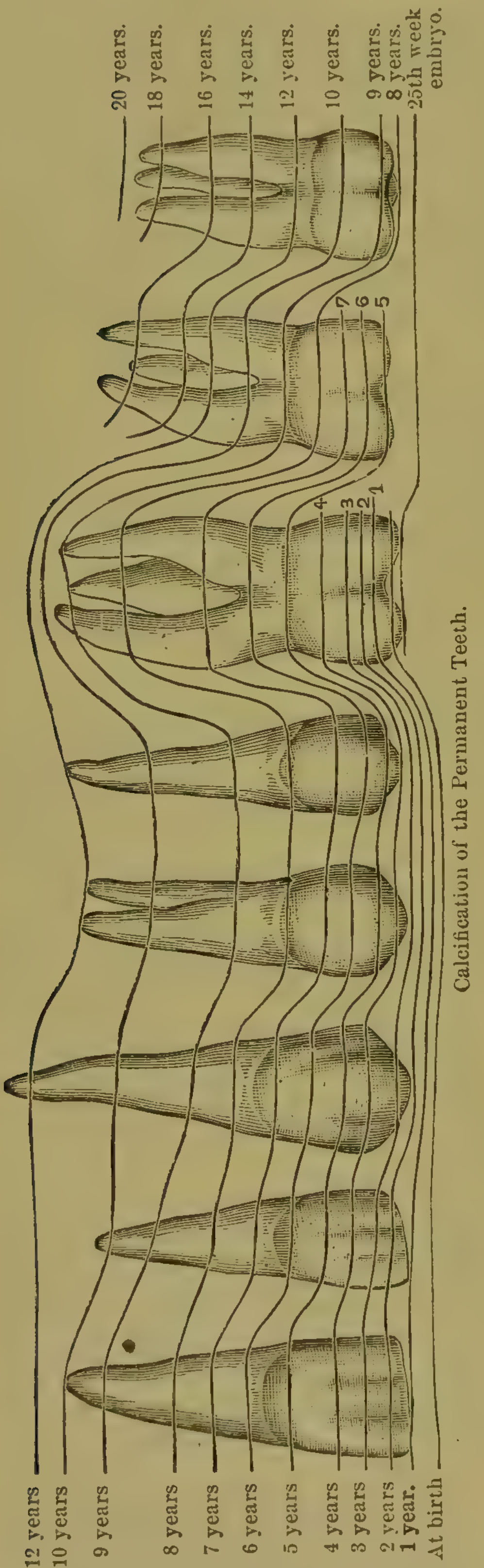
The permanent teeth, unlike the deciduous in embryo, are during the periods of calcification constantly subjected to the influence of morbid systemic conditions, and any abnormal nutritional influence of even a few weeks' duration, if occurring during the period of coronal calcification, is sure to make an impression upon the crowns of the teeth which are at that time undergoing this process, markings or structural defects being located at the point of calcification, and limited in extent or modified by the severity and duration of the systemic abnormality occasioning it.

Fig. 258, though given in Vol. I. in Dr. Sudduth's article, to which allusion is made above, is repeated in connection with this text, because in the subjoined table the age at which calcification begins is given, and the value of noting its progressive periods will be seen when one desires to determine the age of the child at the period the systemic condition existed which caused the structural blemish.

If any serious nutritional disturbance occurred prior to the fifth year, the defect would be observed upon the incisors and first molar crowns, varying in location with the age and advancement of calcification. If prior to the seventh and after the third year, it would be seen on the crowns of the cuspids, bicuspids, and second molars; occurring between the eighth and twelfth years, it would probably produce some malformation of the third molars. This influence of the general health upon the teeth, inducing vices of conformation, may be assigned as a very important factor, favoring the premature loss of this the third molar. Development in it proceeds or is protracted through a period of childhood when the system is liable to frequent and prolonged attacks of malnutrition, which must unavoidably interfere with perfect calcification.

While the permanent teeth in their eruption rarely produce such suffering and disastrous consequences as accompany temporary dentition, there are times when the cuspids and bicuspids are so retarded in their eruption by either the persistence or the premature loss of their deciduous predecessors, or by a contracted condition of the maxillary bones, that serious trouble results. From induration of the gums or non-absorption of the anterior portion of the ramus or tuberosity the first, second, or third molar may be the cause of much local inflammation and a febrile systemic condition; and this may especially be the case where there is an impacted third molar.

Fig. 258.



Permanent Teeth Commence Calcification.

25th week of fœtal life, enamel and dentine of first molars begin calcification.
First year after birth, central and lateral incisors begin calcification.
Four years of age, cuspids, bicuspids, and second molars begin calcification.

Eight years of age, third molars begin calcification.
Sixth to seventh year, the 4 first molars are erupted.
Seventh to eighth year, the 4 central incisors are erupted.
Eighth to ninth year, the 4 lateral incisors are erupted.
Tenth to eleventh year, the 4 first bicuspids are erupted.
Eleventh to twelfth year, the 4 second bicuspids are erupted.
Twelfth to fourteenth year, the 4 cuspids are erupted.
Twelfth to sixteenth year, the 4 second molars are erupted.
Sixteenth to twentieth year, the 4 third molars are erupted.

By the commencement of the sixteenth year the above table completes permanent dentition, with the exception of the third molars or wisdom teeth. The variability of these is great, for while they are not unfrequently in position by the seventeenth year, they are often unerupted at twenty-five, or are sometimes delayed until the thirtieth or fortieth year. In this greater delay the absence of room in the arch is usually the cause, and not until some of the more anterior teeth are extracted and the alveoli absorbed do they make their appearance. The cuspids and second bicuspids are also less uniform in their eruption than the incisors. This may be due to either the persistence or premature loss of their predecessors. If the deciduous cuspid be prematurely removed, the first bicuspid, which makes its appearance two years before the permanent cuspid, will move forward and take its position adjoining the lateral incisor. This necessitates the delay of the permanent cuspid some months, and when it does erupt it must encroach either on the labial or palatine surface. A similar condition results from the early loss of the second deciduous molar. The first permanent molar coming through more than four years before the second bicuspid, the premature loss of the second deciduous molar would enable the first molar to occupy the space which should be protected for the bicuspid, and force the calcification of the latter beneath the deciduous crown or to occupy a position encroaching upon either the buccal or lingual territory.

A paper of great value from the pen of Dr. J. W. White (see p. 321) ably portrays the dangers of interrupted deciduous dentition, but the associate lesions of second dentition are regarded as of trifling importance. Yet not unfrequently do conditions exist at this period of the child's life which result in very serious constitutional disturbances. A want of correspondence between the growth of the root and the removal of the superimposed structures may result in stomatitis, enfeebled digestion, impaired nutrition, and fever. Wherever the terminal branches of the trifacial are distributed suffering, severe and protracted, though quite remote from the seat of the disturbance, will until the cause is removed baffle the best efforts of the physician to relieve. The persistence of either the inflamed and swollen or the indurated gum over the crowns of the advancing first, second, or third molars, retarding their eruption and pressing the sharp edges of the calcifying roots back into the uncalcified pulps or formative papilla, cannot do less than encourage, if not produce, disorders of too serious a nature to be disregarded, and second to those of first dentition only because the increased age has lessened the child's liability to disease and increased its nutritional advantages and its resisting power. An impacted third

molar at the base of the coronoid process is capable of giving as much excruciating and persistent suffering as it is possible for human nature to endure. Indeed, there is no abnormality or lesion coming in the province of the oral surgeon which demands more prompt action or for the time more thoroughly taxes to the utmost his best judgment and skill. The removal of the anterior molar is often indicated for the purpose of giving relief; indeed, when the third molar is imbedded so that it cannot be reached, it is the only remedy. In reference to the treatment of less severe cases, Louis Starr, M. D., in writing in the *Physician and Surgeon* on the "Eruption of the Permanent Teeth and their Disorders," says: "Free lancing of the gums over molars; the application of cocaine to painful gums surrounding loose temporary teeth; the extraction of these when the substituting teeth are so advanced as to run no risk of impairing the arch of the jaw; regulation of the diet and hygiene and the employment of tonics and laxatives,—are the measures to be recommended. The diet must be simple, non-farinaceous, and nutritious; it is better to allow four small meals a day than three large ones."

The Alveolar Process.—Regarding the alveolar process, we cannot do better than appropriate the concise statement of Charles S. Tomes, *Dental Anatomy*, p. 198, where he says: "They were first built up as crypts with overhanging edges enclosing the temporary teeth; then they were swept away in great part to allow of the eruption of the temporary teeth; and next they were rebuilt about the necks to form the sockets of the deciduous teeth. Once more, at the fall of the deciduous teeth, the alveoli are swept away, the crypts of the permanent teeth are widely opened, and the permanent teeth come down through the gaping orifices. When they have done so, the bone is re-formed so as to closely embrace their necks, and this at a period when but little of the root has been completed.

"Take, for example, the first upper or lower molars: their short and widely-open roots occupy the whole depth of the sockets, and reach respectively to the floor of the antrum and the inferior dental canal. No growth, therefore, can possibly take place in these directions; the utmost available depth has already been reached, and as the roots lengthen the sockets must be deepened by additions to their free edges.

"It is impossible to insist too strongly upon this fact, that the sockets grow up with and are moulded around the teeth as the latter elongate. Teeth do not come down and take possession of sockets more or less ready-made and pre-existent; but the socket is subservient to the position of the tooth: wherever the tooth may chance to get to, there its socket will be built up around it.

"During the period of eruption of the permanent teeth the level of the alveolar margin is seen to be extremely irregular, the edges of the sockets corresponding to the necks of the teeth, whether they have attained to their ultimate level or have been but just cut. And when temporary teeth have been retained for a longer period than is normal, they sometimes become elevated to the general level of the permanent teeth (which is considerably higher than that of the temporary teeth),

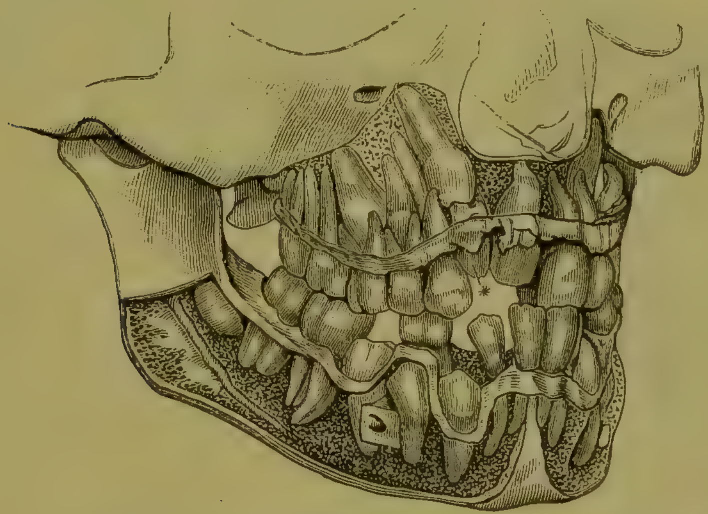
so that they take their share of work in mastication. When this is the case the alveoli are developed round them, and come to occupy with the tooth a higher level than before."

The foregoing fully illustrates the entire dependence of the alveoli upon the teeth—a relation of which dentists constantly avail themselves in the treatment of cases of irregularities.

In reference to the forces which largely determine the position of the teeth, Mr. C. S. Tomes says: "When a tooth leaves its bony crypt, the bone does not at first closely embrace it, but its socket is much too large for it, and a very small force is sufficient to deflect it. And, indeed, a very slight force constantly operating is sufficient to materially alter the position of a tooth, even when it has attained to its full length."

Along the outside of the alveolar arch the muscular lips are exercis-

Fig. 259.



Represents the Jaws and Teeth of a Child about fourteen years of age. The irregular position of the teeth and the close adaptation of the alveolar border to their necks, without reference to the position of the crown, illustrate very fully the entire dependence of the alveoli upon the teeth. The right inferior first molar is seen in the figure to be elevated by the advancing first bicuspid to the same level as the permanent incisors, yet the alveolar border protects its neck, while the adjoining permanent cuspid, occupying a position much below it, carries the same border to its level (Tomes).

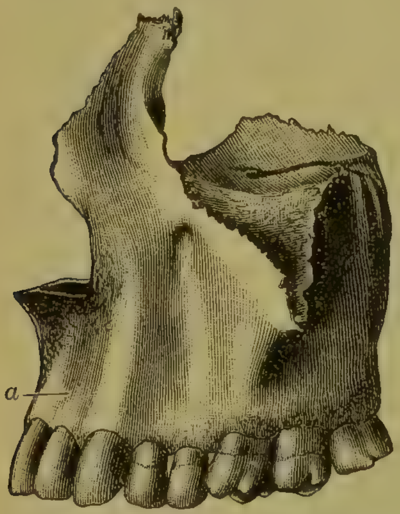
ing a very symmetrical and even pressure upon the crowns of the teeth; so also the tongue is with equal symmetry pushing them outward: between the two forces, the lips and the tongue, the teeth naturally become moulded into a symmetrical arch. That the lips and tongue are important factors in shaping the arch is further illustrated by the results which follow upon the child being forced to breathe through the mouth in consequence of the enlargement of the tonsils. The mouth being constantly open induces an increased tension of the lips at the corners; hence an undue pressure upon the bicuspids as they are being erupted not only produces a high and narrow arch, but also a projection of the anterior teeth, which from the unnatural position of the lips are deprived of their usual adjusting influence.

The several methods by which teeth are attached to their bases are, by a fibrous membrane, by a hinge, by ankylosis, and by implantation in bony sockets. Of these, the last, termed gomphosis, is the normal method

for the human family, and indeed for most of the Mammalia, though from the influence of disease we not unfrequently find teeth ankylosed to the process, and through it to the maxilla, by calcification of the nourishing membrane. Where this union exists it much complicates the effort of extraction, and frequently necessitates the removal of the attached portion.

In this natural method—by gomphosis—there is a special development of bone, which is gradually adjusted to the tooth with a vascularly organized and nourishing membrane intervening. The root is scarcely completed in its calcification before it is securely imbedded in its bony encasement, termed the alveolar socket, with the elastic vascular tissues lying between the two and furnishing nourishment to them both, as well as acting as a cushion, protecting both from injuries which might result from undue mechanical forces either from within or without.

Fig. 260.



Superior Maxillary Bone of Man, left side, the lower border: *a*, alveolar process closely investing the roots of the superior teeth.

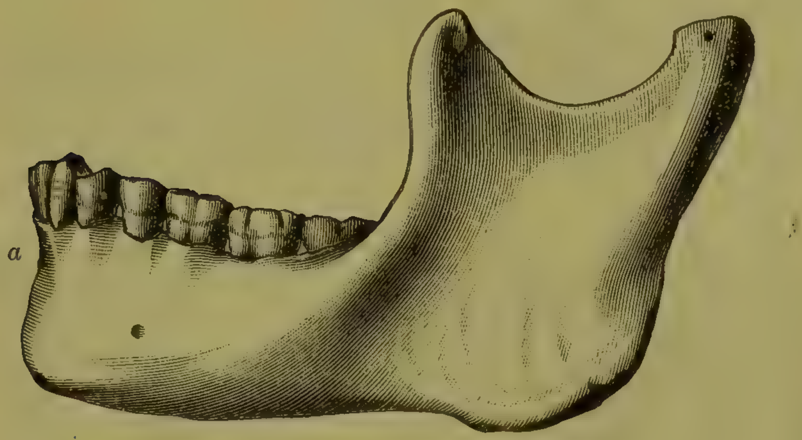
Fig. 260 represents the superior maxillary bone of man, left side. The alveolar process is a strong ridge of bone occupying the inferior border, curved so as to form, with that of the other bone, the elliptical figure which is so characteristic of the dental arch in the higher races. If we examine its structure, we find it consists of two plates—an outer and an inner—which are connected by transverse septa. These septa, in connection with the plates, form the sockets of the teeth, and by their close adaptation, as previously stated, furnish the principal supports which hold them in position.

The internal alveolar plate is much the stronger of the two, while the thinner and weaker external one is taken advantage of in the extraction of a tooth or in the treatment of an alveolar abscess where it is desirable to make an artificial opening into it for the exit of pus. On the external or labial and buccal surface of the process the position of the roots of the teeth are well outlined from the eminences or convexities corresponding thereto. These are especially prominent over the cuspids, owing to the larger antero-posterior diameter of their roots and a perceptibly thicker lamina of process. The edge of the alveoli on the labial and buccal surface of the neck of each tooth is slightly concave, while the septa between the teeth rise to a higher level, giving to the exposed border, when the teeth are all removed, a festooned appearance. The bone is perforated with foramina of varying sizes, giving it a very porous or spongy structure. At the bottom of each socket there is a larger foramen corresponding with the foramen at the end of the root, for the admission of the nerves and vessels connecting the tooth-pulp with the arterial and nervous system.

The lower maxilla or mandible has (Fig. 261, *a*) its upper or superior border constituting the process for the support of the inferior teeth.

The curvature formed by this ridge with that of its other half is somewhat less than that described by the superior arch. It extends from the ramus on one side to the same point on the other, and is broader on its distal ends than on the anterior. The ridge formed by the external and internal plates and septa corresponds in appearance to those pre-

FIG. 261.

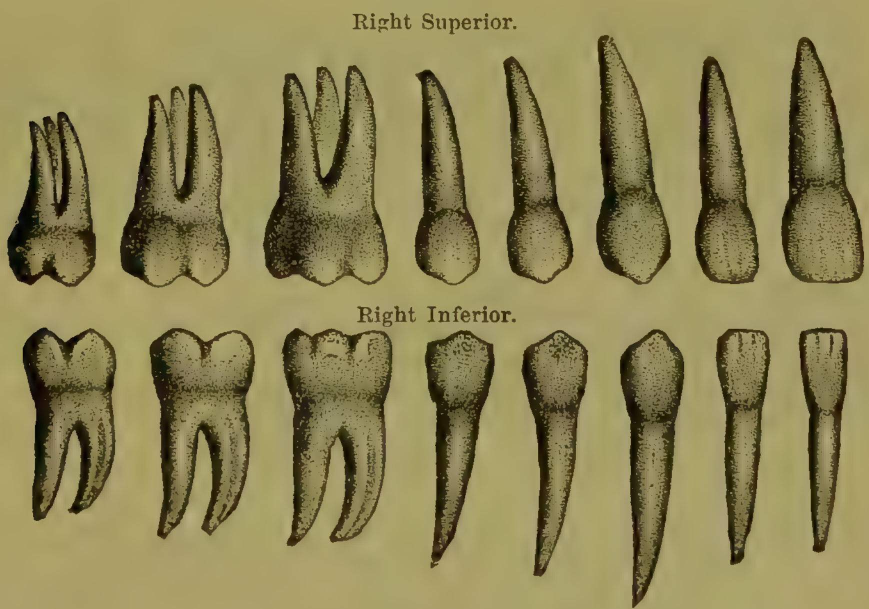


Inferior Maxillary Bone of Man, left side, the superior border: *a*, alveolar process closely investing the roots of the inferior teeth.

sented by the superior maxilla, except that the external plate is thicker and more compact; especially is this the case as it reaches the ramus.

Fig. 262 represents the detached superior and inferior permanent teeth, right side, the labial surfaces of the anterior and the buccal surfaces of the posterior teeth in view, the single roots presenting with

FIG. 262.



Permanent Teeth: front view.

this view the appearance of cones, the base of each cone seen from this surface being the line of the greatest lateral diameter. The teeth with multiple roots have a combination of cones. The longer ones, when in position, are buried in alveolar process; the shorter, on the masticating

surface of the crown, represent the cusps which in number frequently correspond with the roots, and their abortive efforts at division induced by longitudinal grooving, which usually divides the pulp-canal. The anterior teeth, when viewed from their sides or lateral surfaces, also present double cones, the base of each cone being at the neck of the tooth. The roots when deviating from the vertical line are curved posteriorly or toward the ramus.

Figs. 263 and 264 represent upper and lower permanent teeth, vertical section, dividing pulp-chamber in its lateral diameter. The relative position of the pulp in crown and root is shown. In the anterior teeth, incisors and cuspids, the pulp assumes the peculiar wedge shape, which

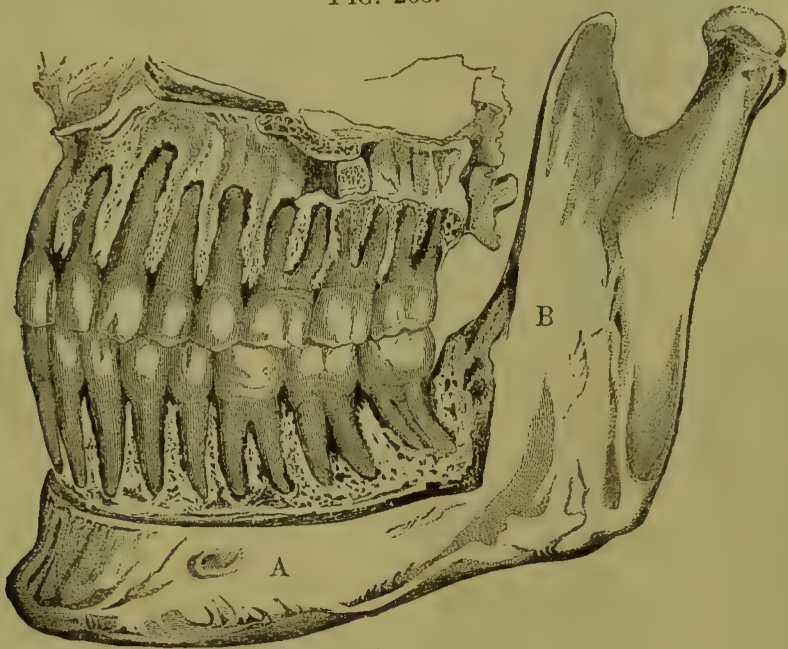
Fig. 263.

Fig. 264.

is represented by this lateral view of the crown. In the posterior teeth, bicuspids and molars, the general outline of the body of the pulp resembles in shape the crown enclosing it, the cornua or horns of the pulp projecting into the cusps more or less prominently in correspondence with their covering. The flattened or compressed roots of the superior bicuspids show the division of the canal into two, terminating in distinct foramina at the apical end, while in the more cylindrical roots of the inferior bicuspids the pulp-canal maintains a corresponding shape.

Fig. 265 gives a view of the teeth *in situ*, the external, labial and buccal, plate of process having been removed so as to expose the position of the roots of the teeth and the close adaptation of the septa, which extend from the inner to the outer wall of the process to the roots

FIG. 265.



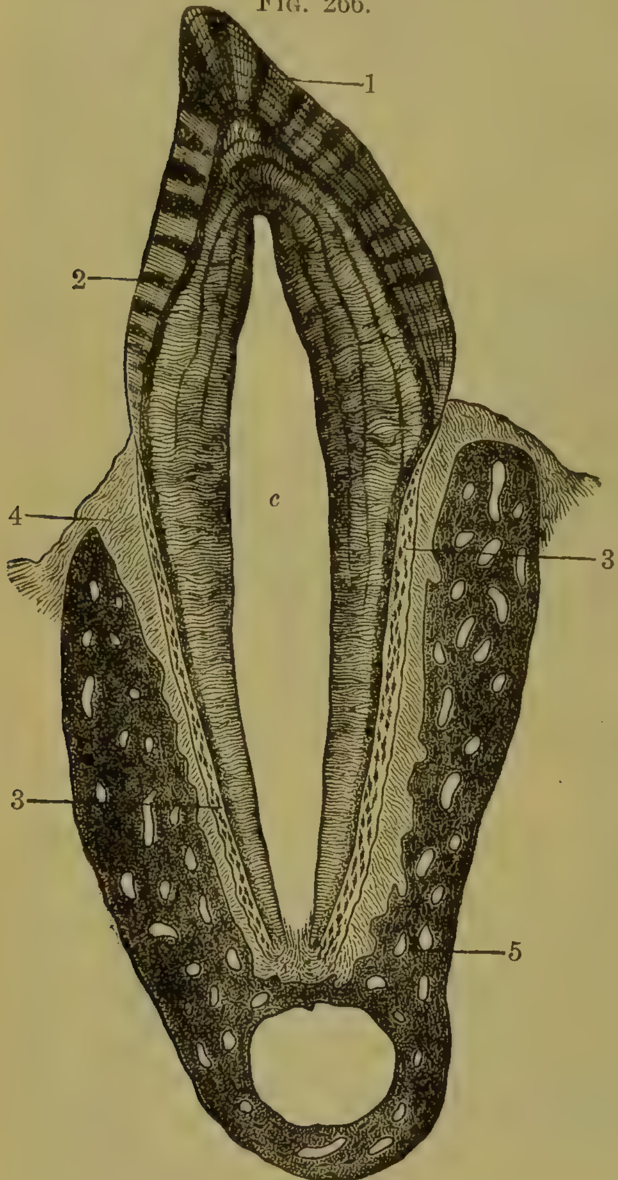
of the teeth, filling up the spaces not only between the roots of different teeth, but also between the roots of the same tooth where they are multiple, forming for each an individual socket. The positions of the apical ends of the roots are also to be noted—in the lower jaw their close proximity to the inferior dental nerve, and in the upper jaw to the floor of the antrum of Highmore or maxillary sinus. In the articulating surfaces we observe that no one tooth in the lower meets only one in the upper, but always, when the jaws are closed, has parts of two teeth antagonizing with it. Another concomitant of a full and normally-developed dental armature is the relative position of the ramus, *B*, to the body of the bone, *A*, they being almost at right angles to each other—a condition quite essential to the most efficient exercise of the function of trituration, which process is effected by the horizontal or lateral motion.

Fig. 266 represents a vertical section of a tooth and the adjacent structures. *In situ* are seen the alveolar process, peridental membrane, cementum, dentine, and enamel; in the centre, surrounded by the dentine, is the pulp-chamber. Within this chamber is placed the pulp, and on the outer walls of the process the mucous membrane, gum-tissue, and periosteum. A horizontal or transverse line drawn from the labial to the lingual surface will intersect the tissues in the order in which they will be briefly sketched.

MUCOUS MEMBRANE.—The first tissue divided is the mucous membrane and gum. The outer surface of this consists of thick pavement epithelial cells arranged in several stratified layers containing the prickle cells (of Max Schultze), uniting the network of adjacent cells by their fine filaments, and permeated by a transparent cement-substance, which

under inflammatory conditions increases to a considerable extent, and hence separates the cells from each other.

Fig. 266.



Vertical Section of a Tooth, exposing to view—1, enamel with radial and concentric markings; 2, dentine with tubules, intertubular tissue, and incremental lines: in its centre is the pulp-chamber, c, surrounded by an unbroken wall of dentine, save the apical foramen; 3, cementum covering the dentine of the root, with its lacunæ or bone-corpuscles; 4, peridental membrane closely investing the cementum and supplying it and the alveolar process with nutrition and sensation, fibres of membrane attached to these bony structures; 5, alveolar process forming socket for support of root, with lacunæ and canaliculi permeating it.

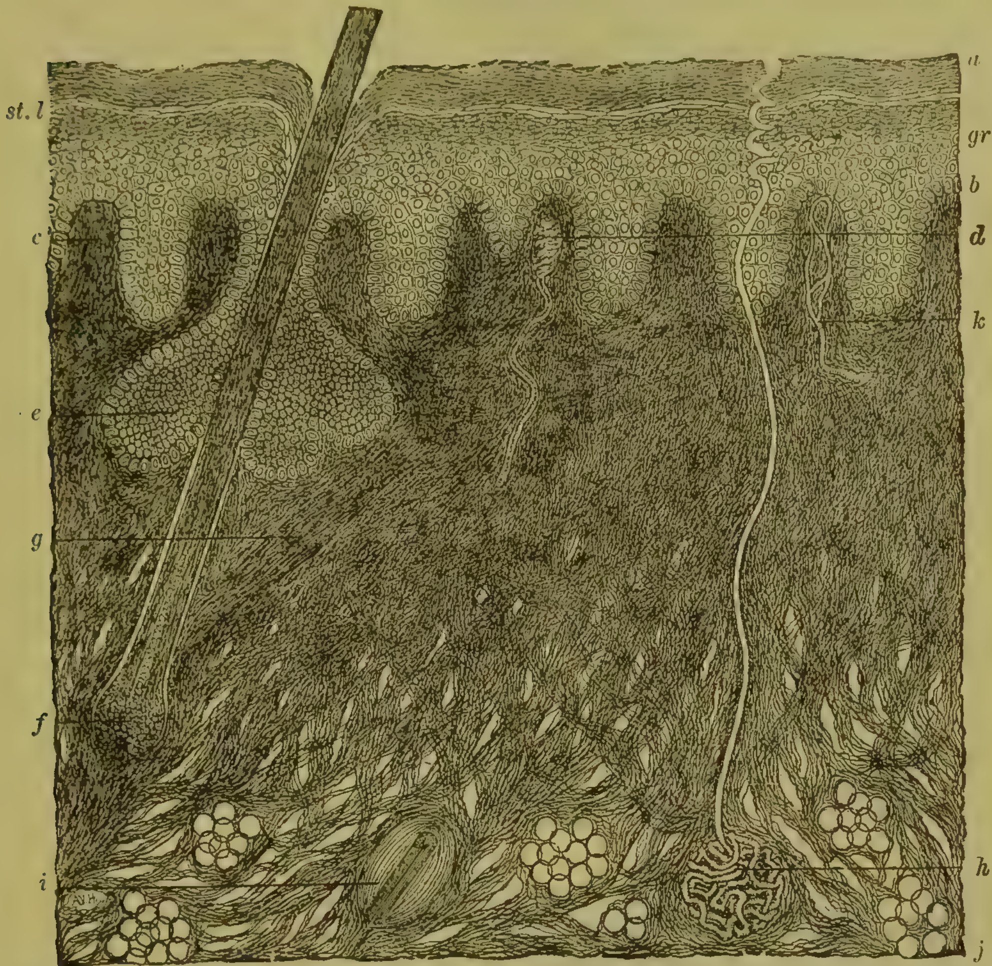
The deepest layer of the epithelium is composed of a greater or less number of columnar epithelial cells, each with a nucleus. Underneath the epithelium is a basement-membrane, a delicate epithelial structure. Then follows the mucosa, a dense connective-tissue membrane, chiefly composed of bundles of fibrous connective tissue crossing each other in various directions. The thickness and firmness of the mucosa vary in different parts; for instance, owing to the nature of its connective tissue and its intimate fusion with the fibrous tissue of the subjacent periosteum, it is much thicker and firmer on the gums and hard palate than at the bottom of the mouth and on the soft palate. It forms a continuity with the connective tissue of the alveolo-peridental membrane.

Allen's *Histology* says: "In the mouth of man the epithelial covering of the mucous membrane is nearly identical with that which covers and protects the skin. The stratum granulosum and the stratum lucidum, however, are absent."

"Moreover, because of the constant moist condition of the epithelial layers upon this mucous membrane, the corneous layer of cells is comparatively thin, and is composed of thin scales in which small nuclei may be seen. The deep layer of columnar cells is but little pigmented. Some later histologists note, throughout mucous membranes and the small accessory glands attached thereto, the existence of a single layer of flat endothelial cells between the epithelium and the connective tissue upon which it rests. The cellular covering of the mucous membrane

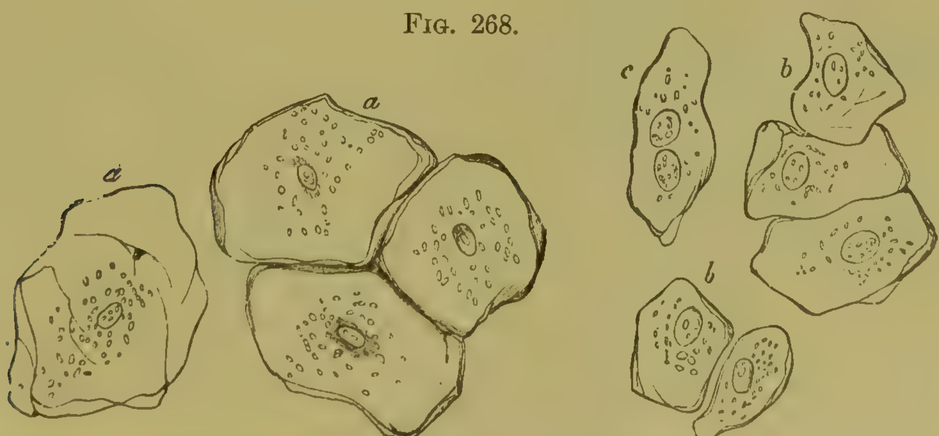
of the oral cavity is therefore to be regarded as a *stratified pavement* of *squamous* epithelium. The epithelial cells of the mucous membranes,

FIG. 267.



Vertical Section of the Human Skin: *a*, corneous layer of the epithelium; *st. l*, stratum lucidum; *gr*, stratum granulosum; *b*, rete mucosum, and papillary layer of cylindrical cells; *c*, papillæ of skin; *d*, tactile corpuscle; *e*, sebaceous gland; *f*, hair-bulb; *g*, erector pili muscle; *h*, convolution of sweat-gland; *i*, Pacinian corpuscle; *j*, panniculus adiposus (fat-layer); *k*, vascular loop (low power, partly diagrammatic—Duhring).

FIG. 268.



Epithelial Cells in the Oral Cavity of Man: *a*, large; *b*, middle-sized; *c*, the same with two nuclei (high power—Gray).

like those of the skin, are slightly separated, yet firmly held together by an intercellular cement."

According to the investigations of some authors (Klein among others), "foreign particles placed upon the surfaces of the mucous membranes are absorbed mainly, if not exclusively, by means of the intercellular cement-substance, which, at the surface of the fibrous tissue, is in direct communication with the superficial lymph-spaces of the connective tissue."

GUMS.—The gums, which protect the superior border of the alveoli and are adapted to the necks of the teeth and intervening spaces, are so called because they were supposed to produce the teeth, the word coming from the Latin *gigno*, "I beget." Gum-tissue is a highly vascular, comparatively dense, and fleshy substance, adapted to sustain without serious injury the forcible contact of the hard portions of food. Its fibrous element gives it great advantage in sustaining its function as a protecting cushion over the alveolar border.

In a healthy state the gums are rather remarkable for their insensibility, bearing with little response the pressure to which they are subjected. The mucous membrane, of which they are largely made up, is unusually thick in this locality; it is reflected around the projections between the teeth and rendered continuous with the periosteum of the alveoli.

Inflammation is the disease to which the gums are liable, but their perverted vascular action has a variety of significations. Systemic disturbances, whether trivial or serious, often find in this tissue a local expression, resulting not unfrequently in its degeneration and subsequent disintegration. It is highly susceptible to the continued mechanical influences of ill-fitting artificial dentures, of tartar, and of crowded, dead, or loose teeth, while in the vascular disturbances of near or adjoining tissues it fully sympathizes.

PERIOSTEUM.—Beneath the epithelium and gum-tissue is a fibrous membrane, the *periosteum*. "It consists of two layers, an outer and an inner, and is continuous at all points except those surfaces covered by articular cartilages and the attachment of ligaments and tendons. The outer layer is composed of one or more lamellæ of dense white fibrous tissue, the direction of whose bundles is parallel to the bone-surface. Among these white fibrous bundles is a number of fine yellow elastic fibres, and in the lymph-spaces formed by the apposition of the bundles are cellular elements similar to those of dense white fibrous tissue. In this external or fibrous layer of the periosteum blood- and lymph-vessels ramify and form networks" (Allen).

"This large group of *fibrous membranes* is usually made to include structures which, though seemingly much separated, are closely connected in their structural peculiarities; and, though they may seem to serve widely different purposes and to be connected with very different organs, they are all emphatically fibrous in their structure, and differ only in the peculiarities of their fibrous arrangement, in preponderance of the white or elastic varieties, and in the number and character of the cells which may be contained within the fibrous network.

"The purposes subserved by these different fibrous membranes when closely studied are found to be as similar as their structure. They are all *coverings* for other structures and form their connections with neighboring parts; and, while in themselves they are indifferent tissues, they

are generally made subservient to functioning tissue by conveying blood-vessels and nerves, and holding in some parts of their network embryonal cells for the supply of the needs of the tissues which they envelop or connect. The inner layer of the periosteum consists of an extremely loose fibrous tissue, the meshes of which are filled by cells very similar to the osteoblasts described as existing upon the trabeculæ of spongy bone. Among these are numbers of elements which present characters similar to those of lymph-corpuscles" (Black).

"This inner layer of the periosteum is richly supplied by blood-vessels, which run among the cells occupying the meshes. Beneath the periosteum the surface of growing bone is covered by a bony network, the meshes of which are crowded by cells which are contiguous with those which fill the interfibrillar spaces of the inner or so-called osteogenetic layer. Here and there the most superficial portion of this bony network sends a pointed and somewhat curved spicule of bone into the depth of the inner layer of periosteum.

"The surface of the trabeculæ forming this osseous network, as well as of the bony spicules which project into this inner layer of the periosteum, are covered by the so-called osteoblasts of Gegenbaur, through the agency of which not only the bony trabeculæ and spicules springing therefrom increase in size, but also the fibrous bundles at the end of the spicules are converted into bone. In this manner the bone grows beneath the periosteum."

"The fibrous membranes act very largely as a dépôt of supplies to the tissues which they invest. They bear the blood-vessels and nerves, and in some cases they receive—partially, as in the periosteum for the bones, and in others wholly, as in the peridental membrane for the cementum—the pabulum from the blood to be transmitted through their meshwork to the point of assimilation. The local characteristics of the individual membranes are continually modified by the deflection of their fibres this way or that to give place for the passage of blood-vessels and nerves, and for the investment of them" (Allen).

Fig. 269.

Osteoblasts from the Parietal Bone of a Human Embryo thirteen weeks old: *a*, bony septa, with cells of the lacunæ or bone-corpuscles; *b*, layers of osteoblasts; *c*, the latter in transition to bone-corpuscles (very high power—Gegenbaur).

According to Dr. Black, "this tissue is distributed throughout the body. It is continuous everywhere, and is described under the utmost variety of names, according to the local peculiarity of the tissue and the positions in which it is found.

"It is found under the mucous membranes—submucous tissue; under the serous membranes—subserous tissue; under the skin—subcutaneous tissue; and about the blood-vessels it forms a continuous membranous sheath or investment, and in this way gives them support and protec-

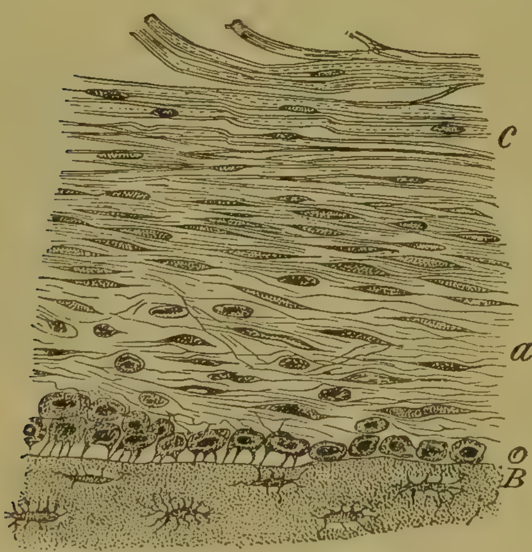
tion. In the same way it forms the investment of the nerves—neurilemma; encloses each muscle in a distinct sheath—myolemma; and, dipping in between the muscular fibres, surrounds each one individually—sarcolemma; and serves to connect them with their tendons or with the periosteum. It invests the glands, holding their lobes in position, and, following the ducts into the substance of the gland, forms an investment for each lobule, and within this substance the blood-vessels that supply the gland ramify. It forms the support for the organs of the hollow viscera—peritoneum, pleura; it invests the brain—dura mater, arachnoid membrane, and forms the investment or matrix for its functioning cells—neuroglia; it encloses the heart in a closed sac—pericardium; and forms the investment of the eye—sclerotica. In strong membranous sheets—fascia—it binds down the muscles and holds them in position; it forms the investment of the bones—periosteum; and serves to attach the roots of the teeth to their alveoli—peridental membrane. In a still more condensed form, in which the fibres lie parallel with each other, it forms the tendons which connect the muscles with the bones, and the ligaments which connect the bones together.

"Though it is widely specialized, it may aptly be termed the *tissue of support and motion,* while the tissues of the epithelial type constitute the *tissues of function and protection*" (Black).

Histologically, the periosteum is composed of fibrous tissue, in the meshes of which are found certain cellular elements. It presents for examination—

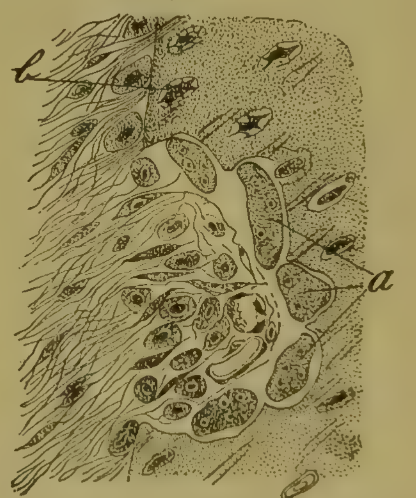
1. An outer layer of coarse white fibrous tissue (*c*, Fig. 270);

FIG. 270.



Section of Bone and Periosteum covering it: *B*, bone; *c*, outer fibrous layer; *a*, inner layer of white fibrous tissue: *O*, layer of osteoblasts, some of which reach the bone with their prolongations (Black).

FIG. 271.



Section of Bone and Periosteum covering it: *a*, osteoclasts, cells that absorb bone; *b*, surface of bone, showing fibres of periosteum penetrating it (Black).

2. An inner layer of fine white fibrous tissue (*a*, Fig. 270);

3. Elastic fibres;

4. Penetrating fibres, or fibres of the periosteum that in the growth of bone are included in its substance;

5. Osteoblasts, or a layer of cells that lies between the periosteum and the bone (*o*, Fig. 270);

6. Osteoclasts, cells that absorb bone (*a*, Fig. 271).

"The white fibrous tissue is everywhere disposed in two layers, an inner and an outer, or a layer of coarse fibres forming the outer portion, and a layer of fine fibres forming the portion next to the bone. The yellow or elastic fibres are found mostly intermingled with the coarse fibrous layer. They are usually very difficult of observation, and do not, as a rule, appear in sections as ordinarily prepared."

Outer Layer.—"The size and arrangement of the coarse fibres in the formation of the outer layer is exceedingly variable in different regions of the osseous system. On the long bones they are generally smaller than upon the short, while the largest fibres are about the bones of the face. The rule is, that the periosteum, as a whole, is thicker and stronger at exposed points where the bones are near the surface, and is more delicate when deeply covered with other tissues. Hence we find it thin and its fibres correspondingly delicate on the shafts of the long bones."

Internal Layer.—"The internal layer is of an entirely different character from the outer, both in the nature of its fibres and in their arrangement. It also presents great diversity of arrangement. In the consideration of this layer it will be convenient to divide it into *attached* and *non-attached*, as it presents notably different characters in its fibrous structure and in the relation of its fibres to the bone which it clothes."

"The *non-attached inner layer* of the periosteum is separated from the bone almost completely by an intervening layer of polygonal or flattened cells, the osteoblasts (*o*, Fig. 270); none of its fibres pass into the bone; while in the attached periosteum those of the inner do pass into it or seem to spring out of it.

"It is apparent at *a*, Fig. 270, that the fibres in the portion next to the layer of osteoblasts are more inclined to a direction horizontal to the surface of the bone; while in the portions next to the coarse fibrous layer their general direction has become perpendicular or more or less inclined to the surface of the bone."

"In the *attached portions of the periosteum* the fibres of the internal layer exhibit a definite arrangement. This presents certain variations at different points, but these are only modifications of a definite plan. Here the fibres are not separated from the bone by the layer of the osteoblasts, but spring directly out of the bone between the osteoblasts."

"The *blood-vessels* of the periosteum are numerous and present considerable variation in different localities. On the shafts of the long bones the larger vessels usually run in a direction parallel to the long axis of the bone, and lie between the periosteum and superimposed tissues or on the surface of the periosteum. These branch laterally and anastomose in such a manner as to form a tolerably continuous network."

"In the portions of the periosteum with which the fibres of the mucous membrane or the skin are intimately blended the position of the blood-vessels is notably irregular; indeed, they seem to pertain rather to the superimposed tissue than to the periosteum, and send frequent branches through the latter to the Haversian canals of the bone."

"The *nerves* of the periosteum are generally few in number; however, a considerable number of the larger vessels are accompanied by a small bundle of nerves, which are probably distributed mostly to the blood-vessels themselves. They enter the bones with most of the larger branches of the blood-vessels. At some points nerves passing through the periosteum to enter the canals of the bone are very frequent. These are points where the nerves are required by organs situated within the bone. The supply of the peridental membranes renders them frequent in the periosteum of the alveolar process."

"The osteoblasts, osteoclasts, and fibroblasts are developed from the connective-tissue cells which have their origin in the cellular element of the periosteum."

"The fibroblasts reconstruct or augment in number the fibres of this membrane."

"The osteoclasts, myoplaxes, or giant-cells present various forms: their function is to dissolve the bone with which they are in contact; they are seen in Fig. 271, *a*, in the excavated areas of the bone, conforming in size and shape to the excavations which they have induced."

"The osteoblast has a clearly-defined function, limited to the formation of bone. There is no growth of bone without its presence. They are seen in Fig. 270, *o*. In this figure they are reaching to the bone by extending process-like prolongations. While calcification in various tissues may go on without their presence, the product is not true bone. The osteoblasts are polygonal cells which lie upon the surface of the bone, and usually clothe it as epithelium clothes the mucous membranes. They vary greatly in size and shape with different positions and varying conditions" (Black).

Alveolar Process.—The alveolar process, having received considerable attention in connection with the development of the roots of the teeth, will be dwelt upon here but briefly. It has its origin from the mesoblastic layer. It is clothed externally with a coat of epithelium from the epiblastic layer. The surface of the growing bone is not smooth or compact, but constantly presents convolutions or projections occasioned by the upward growth of spiculæ.

The process occupies the lower border of the superior maxillary bones, extending from the symphysis or anterior border where the two unite to the tuberosity, a rounded eminence of bone just behind the posterior inferior angle. It is broader behind than in front, and is composed principally of cancellous or spongy tissue. Its curvature in outline corresponds to the body of the bone above it: this, however, varies greatly with the race or ancestral conditions of the individual from whom the bone is taken. In a well-formed jaw the general shape of the alveolar border is that of a parabola. It is composed of two plates—an inner and an outer—which, with the septa uniting them, form the alveoli or sockets for the reception of the roots of the teeth.

In the inferior maxillary bone the process occupies the superior border, and extends from the ramus on one side to its fellow on the other. It is, as on the superior bone, broader posteriorly than in front, and is also like it in being formed of internal and external plates united by septa, forming sockets for the reception of the roots of the

inferior teeth. The external plate of the superior maxilla is thin throughout its entire length, so that the roots of the teeth are well outlined, and often bared by the absorption of their scanty covering. On the inferior maxilla the external plate is thick and compact, rendering the inferior molars more firmly fixed in position and more difficult of extraction. For a description of the minute structure of

FIG. 272.

A View of the Alveoli, from which the roots of the superior and inferior permanent teeth have been removed: *a*, *a*, inferior view of superior maxillary bones; *c*, palatine processes; *d*, *d*, malar process; *e*, *e*, tuberosities. The oval and circular spaces are the margins of the alveolar borders from which the roots of sixteen superior teeth have been removed; *b*, *b*, the superior view of the inferior maxillary bone; *f*, *f*, condyles; *g*, *g*, coronoid process. The oval and circular spaces represent the alveolar border from which the roots of the sixteen inferior teeth have been removed.

the bones and illustrations, see Vol. I. p. 39, where Dr. Cryer has examined it in five divisions—viz. the Haversian canals, the bony lamellæ, the Sharpey or perforating fibres, bone lacunæ and canaliculi, and bone-cells.

Dr. Black, in a paper upon bone-formation, says: "The processes of bone-formation and of its absorption are going on simultaneously in very close apposition. Osteoblasts appear over a large part of the sur-

face, but at some points absorption is in progress; osteoclasts are shown to be present, and by the absorption overbalancing the deposit of bone the space in this way is gained for the bone-marrow." In all these varying phases of bone-formation it will be noted that the active agents are the osteoblasts. These seem to be developed in the inner layer of the periosteum, or with equal facility in the tissue that fills the Haversian canals, or the endosteum. They are therefore not peculiar to the periosteum, but belong rather to the surface of the bone, whether this surface be an external or an internal one.

PERIDENTAL MEMBRANE.—Of the several names, peridental membrane, alveolo-peridental membrane, pericemental membrane, dental periosteum, pericementum, employed to designate the tissue supplying the cementum of the tooth with sensation and nourishment, and thus connecting it with the arterial and nervous systems, the writer prefers the term peridental membrane.

The literature upon the histology of this vascular tissue is very limited; indeed, with the exception of short papers from Charles S. Tomes, one from Dr. L. C. Ingersol, and two or three from Dr. G. V. Black, nothing of importance has recently appeared in print; so that for what we shall have to say upon this subject we are largely indebted to Prof. Black's exhaustive papers now in course of publication in the *Chicago Dental Review.*

The peridental membrane comprises that tissue intervening between the root of the tooth and the bony walls of its alveolus. The office of this membrane may be regarded as threefold—functional, physical, and sensory. Functional, in so far as it is the matrix or mother of the development of the osteoblasts, which build up portions of the alveolar walls, and of the cementoblasts, which construct the cementum. "These cells seem to be received into the fibrous meshes of this membrane from the blood-supply as leucocytes or amœboid cells, and here undergo their development or that differentiation which fits them for the building of bone on the one side and of cementum on the other. During this development they become allied to their respective places or harmoniously adjusted to their individual tissues—*i. e.* the surface of the bone and the surface of the cementum" (Black).

The physical function is the fixation of the tooth in its position and its protection from shock in a sudden or forcible occlusion—passive functions which are performed by the fibrous elements. These fibres, designated as the "principal fibres," form the bulk of the tissue of the membrane. They are fixed in the cementum of the tooth's root on the one side, and in the bone which forms the walls of the alveolus on the other, and are thus stretched across the intervening space in various directions, and in such a manner as to suspend the tooth in its socket.

"The sensory function is supplied by an abundance of nerves which enter the membrane from every direction—*i. e.* through the walls of the alveolus, at the apical space, and by the way of the gingival border and over the rim of the alveolus."

"Besides the osteoblasts and cementoblasts, the membrane presents various cellular elements, such as fibroblasts for the augmentation or renewal of its fibrous tissues, osteoclasts for the removal of the walls

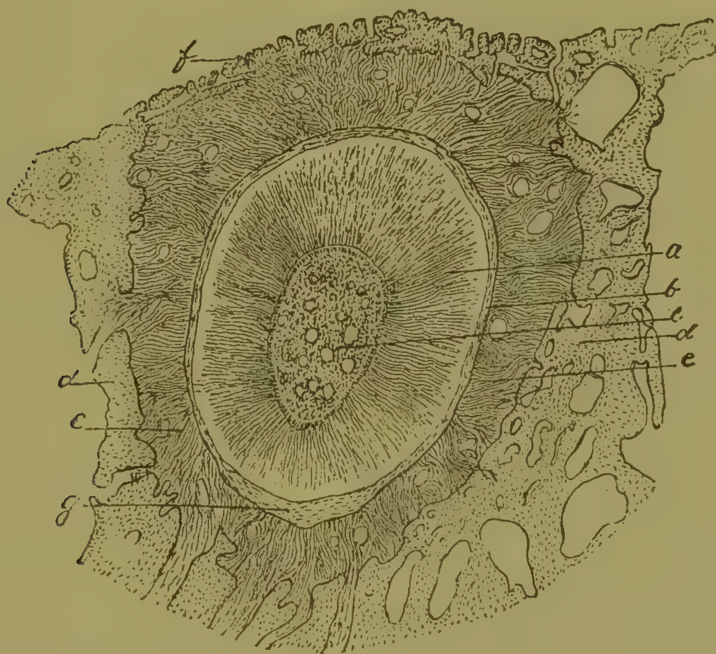
or portions of the walls of the alveolus for the accommodation of changes in the position of the teeth, or of the cementum for the change of the form of the tooth's root.

"Besides the cells mentioned there is always a considerable number of undeveloped cells within the meshes of the fibrous tissue in young subjects, but not many in the old. There is also a set of lymphatics which are peculiar to this membrane" (Black).

The peridental membrane is so formed and arranged as to closely invest the root of the tooth and fill the space between it and its alveolus; even more than this, for it protects the cementum of the root beyond the alveolar border up to its union with the enamel, and extends below the apical end of the root, as seen in Fig. 266.

The membrane varies in thickness very much in different individuals, and in the same teeth at different periods of life, as well as different teeth in the same individual. In Fig. 273, section of a

FIG. 273.



Transverse Section of the Root of an Incisor: *a*, dentine; *b*, cementum; *c*, pulp; *d*, *d*, alveolar wall; *e*, *e*, peridental membrane; *f*, thin surface of labial alveolar wall; *g*, thick portion of cement; blood-vessels cut across are seen in peridental membrane (Black).

temporary incisor, is given a very accurate outline of a cross or horizontal section of the alveolus with its contents. The direction of the fibres of the membrane are well indicated. The differences in the thickness of the membrane, as seen in the figure, seem to correspond with irregularities in the alveolus, which is constantly undergoing modification by its absorption and rebuilding. The general form and extent of the membrane would be better seen in a vertical or lengthwise section.

Those fibres which are fixed in the cementum, and thence stretch across and are fixed in the alveolar wall or into some other tissue, as the fibrous mass of the gums, thus serve to maintain the tooth in its position. Dr. Black terms these the "principal fibres" of

the peridental membrane, and of the first importance in its study; for, with the exception of some deviations from the usual course of these for the accommodation of the blood-vessels and nerves, the other elements are so disposed as not to interfere materially with their arrangement.

Beginning with the gingival portion, he finds the principal fibres firmly fixed to the cementum, literally springing out of it, and passing directly out or but slightly divergent from all the surfaces of this part of the tooth. The bulk of the fibres lie parallel with each other, deviating, as stated above, only to give place to blood-vessels and nerves or the larger group of lymphatics.

The fibres on the lingual and labial surfaces of the incisors after passing out some little distance from the tooth are lost in the coarse, tangled fibrous tissue of the gums. Nearer the border of the alveolar wall the fibres pass on under the gum-tissue proper, and are continuous with the outer layer of the periosteum of the surface of the alveolar walls. As these pass the margin of the alveolus, fibres springing out of the bone first decussate with, and then become mingled with, them, thus forming a very firm support to the gingivus. This bundle of fibres has been termed the dental ligament.

Fibres pass in a curved course over the margin of the alveolar wall from one tooth to another, being fixed in the cementum of each. Blood-vessels may also be seen, which cause more or less deflection in the course of individual bundles of fibres.

The gingivus, or free border of the gums, is covered with a moderately thick but very dense epithelial coating, surmounted upon the fibres emanating from the cementum of the neck of the tooth and the dense tangled mass of fibrous tissue forming the gums.

The fibres of the membrane vary much in different localities; for instance, those at the neck or margin of the alveolus pursue a wavy course, with inclination toward the root as they cross to the opposite border, while those from the middle of the root run almost directly across, and those toward and at the apex of the root incline in their transit toward the crown—all being more or less irregular. Their disposition to form into fasciculi or loose bundles is recognized in the diagram.

This arrangement of the fibres, if studied with reference to the physical functions of the membrane, is most admirable. A strain upon the crown of the tooth, it matters not from what direction the force is applied, is tolerated, and limited, and finally overcome, by this distribution of the fibrous element.

With advancing years the cementum and alveolar walls are usually thickened: this necessarily diminishes the bulk of the membrane and shortens its fibres, which gives them the appearance of passing more directly across from one hard tissue to the other.

The absence of elasticity in the membrane is due to the fact that its fibres are wholly of the white or inelastic connective-tissue variety.

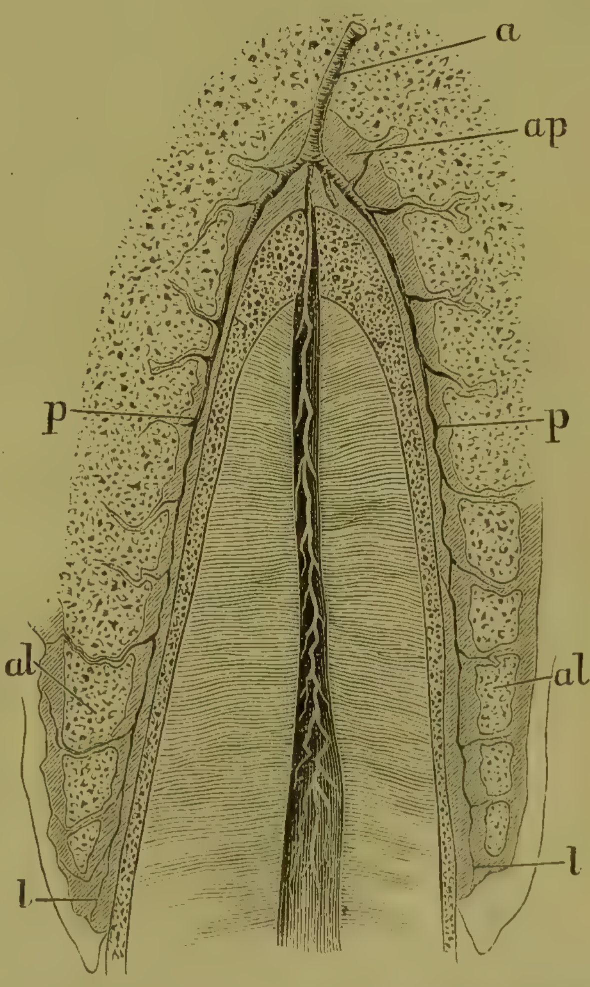
The fibres in some localities are large and strong, and act as a ligament in fulfilling their passive function of holding the tooth firmly in position; yet they are not of that nature, for they stand perceptibly

apart, with other elements intervening, which is not the case with tendons or ligaments.

The parallel arrangement of the fibres is much disturbed by the lymphatics, as well as by the nerves and blood-vessels, the latter occurring about midway between the bone and cementum, and causing irregularity in the course of the fibres of this region by deflecting them to the one side or the other of those important structures.

In the foregoing the effort has been made to describe what Dr. Black has termed the "*principal fibres of the membrane.*" In addition to these, and among them, are a considerable number of fibroblasts, accompanied by very fine fibres, which pass between the principal fibres and often pursue an independent direction. These the same author has termed interfibrous or indifferent tissue, and states that they seem to pervade the entire membrane, and are found wherever the principal fibres are absent or are coarse enough for them to be distinguished. The interfibrous tissue is seen to be ordinary fibrous connective tissue, containing the usual fibroblasts and running its course diagonal to the principal fibres, and, while pursuing no very definite direction, has a general tendency to lie horizontal to the cementum. This tissue does not seem to attach itself to the cementum or bone, as do the principal fibres, though it offers an investment to the blood-vessels and nerves in addition to the tissue which properly belongs to their walls.

FIG. 274.



Root and Membrane of Tooth: *p*, *p*, peridental membrane; *ap*, apical space; *a*, artery; *al*, *al*, alveolar process; *l*, *l*, what is termed dental ligament (Black).

BLOOD-SUPPLY. — The blood-supply of the peridental membrane is very bountiful in the young, and, though it is much diminished with the thinning of the membrane as age advances, the vessels remain fairly abundant.

In the young subject, as stated above, there is a very well-marked vascular area lying centrally between the cementum and alveolar wall, or often rather closer to the cementum. This is well illustrated in the cross-section, Fig. 273.

The large arteries enter the alveolus mostly at the apical space, or rather one or two vessels enter here and immediately

break up into smaller ones. One or two of these enter the root-canal to supply the pulp of the tooth, while the others (from four to six or eight) pass down along the sides of the root and supply the peridental membrane. In their passage down the membrane these divide into many branches, a considerable number of which enter the Haversian canals of the alveolar walls or receive branches from that source. The connection between the circulation of the tissues outside the alveolar wall and the peridental membrane is very free in the young, and, although the bone becomes much more dense with advancing years, it is still fairly well maintained.

There are some vessels which are continuous from the apical space to the gingivus: these in their course are giving off and receiving branches from the alveolar wall, and many of these can be traced through the bony structure to their connection with the larger vessels of the gum-tissue.

As large vessels are not seen in connection with the cementum, these in their course through the peridental membrane give origin to a rich capillary plexus which supplies this tissue. At the border of the alveolus the vessels of the peridental membrane anastomose freely with those of the gum; in this way the gingival border is well supplied with blood. The veins accompanying them stand a little apart from the larger arteries.

By this arrangement of the circulation, even though an abscess or an accident may cut off the supply of blood from the apical source, it is well maintained from the gum-tissue and alveolar walls.

Nerves.—The sensory function of the membrane is supplied by nerves entering it in company with the blood-vessels. The principal bundles enter by way of the apical space, and then divide, a portion to the pulp through the apical foramen, and a number pass down the sides of the root, supplying the membrane and cementum; others enter through the walls of the alveolus by way of the Haversian canals. These traverse the membrane, giving off smaller bundles which are lost in the tissue, until the gingival border is reached, where, in company with those from the gum-tissue, a rich plexus is formed. It is through this supply of nerves that the peridental membrane becomes the organ of touch for the tooth. When the tissues are in a normal condition the tooth will withstand severe pressure or a succession of moderate blows without exciting the peridental membrane to pain. When, however, the membrane is the seat of inflammation, it responds to the slightest touch, or when normal it will, if mutilated, speak in unerring language. Yet this rich supply of nerves and blood-vessels gives the membrane a great recuperative power, which is manifested in its marked tendency to recover from severe injuries.

Lymphatics.—The lymphatics of the peridental membrane embrace a peculiar system of cells. In the young they are found in great profusion lying among the fibres close to the cementum. They are thoroughly specialized and peculiar to this particular portion of the membrane. They occur chiefly in the form of rows of cells insinuated between the fibres: they anastomose freely with each other, and form a network over the whole of the root of the tooth, close to, but not in contact with, the

cementum. The individual cells are like those of the lymphatic glands, and in the larger groups they are seen to be enveloped in a very delicate limiting membrane.

Dr. Black draws some very interesting conclusions regarding the influence of these lymphatic cells in destructive pericementitis. In one specimen he examined, where the disease had not made any observable progress, though there was some slight redness of the gingivus, he found that some of the lymphatics near the gingival border of the membrane were in a state of suppuration : this condition, he says, followed the lymph-chains in the direction of the apex of the root to a distance that surprised him, considering the slight signs of disease visible before operating.

This case indicates that these lymphatics are the seat of this most destructive affection. It seems also that it is these glands which are first affected in salivation with mercury when the gums are "touched" and the teeth sore when pressed together. Also when the teeth become sore from some constitutional condition it is because some agent in the blood affects these glands.

Osteoblasts.—The osteoblasts of the peridental membrane are found on the inner surface of the walls of the alveolus, and in greater abundance in the young than in those advanced in years. They lie on the bone between the principal fibres, with generally many young cells accompanying them : some localities, even in young subjects, will be found almost destitute of these cells, while others, at only a short distance, will be crowded with them. In areas of activity, where the bone is being built up to accommodate some change in the position of the tooth or where the process is thickening, they are in profusion.

(In the foregoing, for what we have written of the periosteum and peridental membrane, as previously stated, we are largely indebted to Professor G. V. Black's papers, lately published in the *Chicago Dental Review*. These articles, so exhaustive in text and so exquisitely illustrated with some seventy figures, we learn from the author are to be put into book-form, which will make them invaluable to every dental and physiological student.)

Before closing what we shall have to say upon this important tissue, a few paragraphs from Charles S. Tomes's *Dental Anatomy* will add to its interest :

"The alveolo-dental periosteum, or root-membrane, is a connective tissue of moderate density, devoid of elastic fibres, and richly supplied with nerves and vessels. It is thicker near to the neck of the tooth, where it passes by imperceptible gradations into the gum and periosteum of the alveolar process, and near to the apex of the root. The general direction of the fibres is transverse; that is to say, they run across from the alveolus to the cementum without break of continuity, as do also many capillary vessels. A mere inspection of the connective-tissue bundles, as seen in a transverse section of a decalcified tooth in its socket, will suffice to demonstrate that there is but a single 'membrane,' and that no such thing as a membrane proper to the root and another proper to the alveolus can be distinguished; and the study of its development alike proves that the soft tissue investing the root and that lining the

socket are one and the same thing; that there is but one membrane—namely, the alveolo-dental periosteum. At that part which is nearest to the bone the fibres are grouped together in conspicuous bundles; it is, in fact, much like any ordinary fibrous membrane. On its inner aspect, where it becomes continuous with the cementum, it consists of a fine network of interlacing bands, many of which lose themselves in the surface of the cementum."

"But although there is a marked difference in histological character between the extreme parts of the membrane, yet the markedly fibrous elements of the outer blend and pass insensibly into the bands of the fine network of the inner part, and there is no break of continuity whatever."

"At the surface of the cementum it is more richly cellular, and here occur abundantly large soft nucleated plasm-masses, which are the osteoblasts concerned in making cementum, and which by their offshoots communicate with plasm-masses imprisoned within the cementum."

"I have never seen the fibres, whether in longitudinal or in transverse sections, pass straight in the shortest possible line from the bone to the cementum; but they invariably pursue an oblique course, which probably serves to allow for slight mobility of the tooth without the fibres being stretched or torn."

"The vascular supply of the root-membrane is, according to Wedl, derived from three sources—the gums, the vessels of the bone, and the vessels destined for the pulp of the tooth, the last being the most important."

"The nerve-supply also is largely derived from the dental nerves running to the dental pulps; other filaments come from the inter-alveolar canals (canals in the bone containing nerves and vessels, which are situated in the septa separating the alveoli of contiguous teeth)."

"It should be borne in mind that the tooth-pulp and the tissue which becomes the root-membrane have sprung from the same source, and were once continuous over the whole base of the pulp. A recognition of this fact makes it easier to realize how it comes about that their vascular and nervous supplies are so nearly identical."

"The human tooth is, accepting as correct the researches of Bödecker, which appear in every way deserving of credence, connected with the living organism very intimately, even though its special tissues are extravascular."

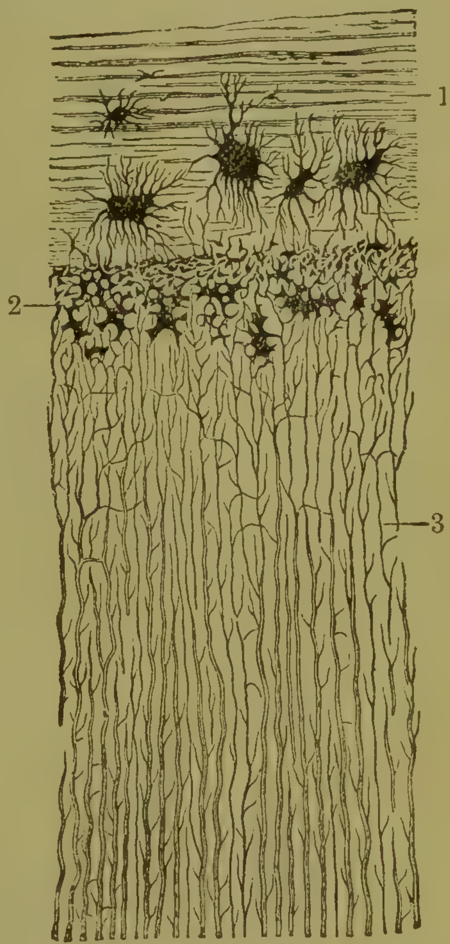
"For blood-vessels and nerves enter the tooth-pulp in abundance; the dentine is organically connected with the pulp by the dentinal fibrils; these are connected with the soft cement-corpuscles, which again are brought by their processes into intimate relation with similar bodies in the highly vascular periosteum. So that between pulp inside and periosteum outside there is a continuous chain of living plasm" (Tomes).

Cementum.—Cementum underlies the peridental membrane, and comes next in the track of our imaginary line.

The dentinal structures composing the tooth are enamel, dentine, and cementum. The relative position of these several tissues is best displayed in a vertical or longitudinal section of a tooth (Fig. 266). The enamel is seen to cover the crown with variable thickness: it is thickest

on the more prominent, the masticating, surface, while at the sides it becomes thinner, and at its terminal edge (the line of its minimum thinness) it has overlapping it a layer of cementum. The dentine occupies the centre and makes up the body of the tooth, extending from beneath the enamel covering of the most pronounced cusp to the terminal end of the root, covered at this latter point by cementum.

FIG. 275.



Transverse Section of the Root, showing cementum and dentine: 1, cementum with large bone-lacunæ and canaliculi; 2, confluent terminal branches of tubuli; 3, tubuli of dentine, with their largest diameters opening on pulp-chamber.

The cementum, like the enamel covering the dentine of the crown, forms a coating of variable thickness over the dentine of the root, and when normally developed its thickest stratum is found at the apical end, giving transit to the nerves and blood-vessels running to the pulp through a foramen which it maintains. The fact that it covers the crown of the teeth of many mammals, and fills up the interstices between the enamel-cusps, is presumptive evidence that it also on a newly-erupted human tooth covers the enamel with a thin coating; indeed, its presence in the sulci of the crown has been thoroughly demonstrated; and the fact that the inner layer of the tooth-follicle serves as the cemental matrix confirms this assumption. So closely allied is cementum to bone that the earlier writers designated it tooth-bone. It consists of a laminated calcified matrix built up from or through the agency of the cementoblasts, just as bone is built up from osteoblasts. Its microscopical structure gives the appearance of periods of activity and periods of rest, modified, as other dense structures are in their growth, by nutritional and morbific influences.

The concentric layers which surround the root are thicker toward or at the apical end than at the neck, the thinnest laminæ being those which cover the margin of enamel at the terminal edges of these two tissues, while from this point, in normally-developed roots, it increases in thickness until it reaches its apical extremity. This tissue is permeated by corpuscles or lacunæ with their prolongations or canaliculi, though in the thinner laminæ, at the neck of the tooth, they are entirely deficient; but in the thicker layers they are to be seen, and where it is thickest at the end of the root the lacunæ are most abundant and largest in size (Fig. 275, 1).

Where hypercementosis exists, and roots of the same or of different teeth are united by its bulk, vascular canals corresponding to the Haversian canals of bone are sometimes found. These corpuscles or

lacunæ are irregular in shape, and often elongated in the direction of the lamellæ of the tissue, and differ from the bone-corpuscles in their processes or elongations, and as much as the osteoblasts differ from the cementoblasts.

The cementum and dentine are, in their nutritional and nervous peculiarities, often connected through the tubuli of the one and the canaliculi of the other, so that not unfrequently, after the pulp has been devitalized, there is still some sensation in the periphery of the dentine through this association.

The lacunæ and their processes are evidently the means through which the cementum maintains its connection with the arterial and nervous systems, and according to Heitzman they contain protoplasmic material.

The corpuscles frequently communicate with each other, and form a network which, from its connection with the peridental membrane, offers a nutritional medium for the whole cemental tissue, maintaining in this way its vitality after the pulp is dead.

Extending through the lamina of cementum are sometimes seen lines, recognized as Sharpey's fibres (Fig. 276). These Charles S. Tomes thinks may be calcified bundles of connective tissue.

FIG. 276.

Some of the Bony Lamellæ from an intermediary or interstitial system, forcibly stripped off after decalcification of the bone, showing the bone-corpuscles and the fibres of Sharpey, *c* (Allen).

The fibres of the peridental membrane enter and become attached to its surface with a firm hold, and connect this tissue with the alveoli or with the cementum of an adjoining tooth, where they extend from one tooth to the other above the alveolar margins. The force of these fibres in their attachment to the cementum is readily recognized by the displacement of a tooth with a pyorrhœa pocket on one side, severing the attachment of the fibre with the cementum, while the other remains normal; the force exerted by the normal attachment is most marked.

The cementum is the least dense of the three dental tissues, and is,

chemically, almost identical with bone. Von Bibra found organic matters, 29.42; inorganic, 70.58—composed as follows:

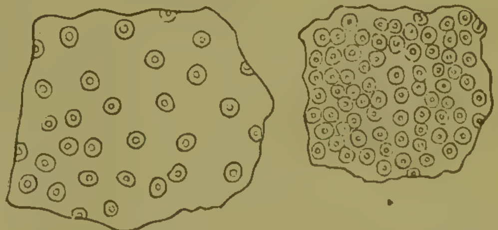
Phosphate of lime and fluoride of calcium	60.73
Carbonate of lime	8.02
Phosphate of magnesia	1.00
Salts	0.83
Cartilage	28.70
Fat	0.72
	100.00

DENTINE.—The dentine forms nearly the whole solid portion of the tooth, and is made up of tubuli and intertubular tissue; its development has been fully described in Vol. I. pp. 356 and 592. It gives protection to the dentinal pulp, and is nourished by it. The tubes (Fig. 275, 3) which permeate it open with their largest diameter on the pulp-chamber, and radiate from this to the periphery of this tissue, terminating beneath the enamel in loops and smaller branches. These latter, becoming confluent, form what is known as the interglobular spaces or the granular layer of Tomes (Fig. 275, 2). The walls of the tubuli of the dentine are described as the calcified dentinal sheath of Neuman, made dense by infiltration with the carbonates and phosphates of lime. When a thin section of dentine is mounted dry, these canals or tubules are filled with air, and when examined by transmitted light they appear dark, as do also the interglobular spaces. These latter much resemble the lacunæ and canaliculi of bone when it is similarly prepared.

Klein states that the fibres which occupy the tubuli are the elongated processes from the inner row of the double layer which covers the pulp, and that the more blunt processes from the outer row of odontoblasts are those which become calcified and form the interstitial substance between the dentinal canals.

If a transverse section of dentine be taken from the wall of the pulp-chamber and magnified, it presents the appearance of being filled with small holes: these openings represent the calibre or orifices of the tubes which have been cut across, though much exaggerated in the accompanying cut. The parietes or walls of the tubes have the appearance of being as thick as the diameter of the canal, and these, in conjunction with the granular mass which cements the tubes together, constitute the walls of the pulp-cavity (Fig. 277). Starting from the pulp, and assuming that the chamber which holds this vascular tissue (pulp-chamber) is the central axis of the dentine, the tube takes a radiate course from this cavity toward the surface or periphery of the dentine, running almost at right angles from the surface which forms their starting-point. As the external surface or circumference of the dentine is greater in bulk than its centre, the tubes must not only pursue a wavy course in their route to their termi-

FIG. 277.



Transverse Section of Dentine, showing tubules cut across. The appearance of the double contour is so much exaggerated as to make the figure almost diagrammatic (Tomes).

nation, but, in order that the dentine shall be equally permeated by them, numerous branches must be thrown off from both sides of the tubes; and again, for the same purpose in some localities, a single tube assumes a peculiarly spiral arrangement from its origin to its termination.

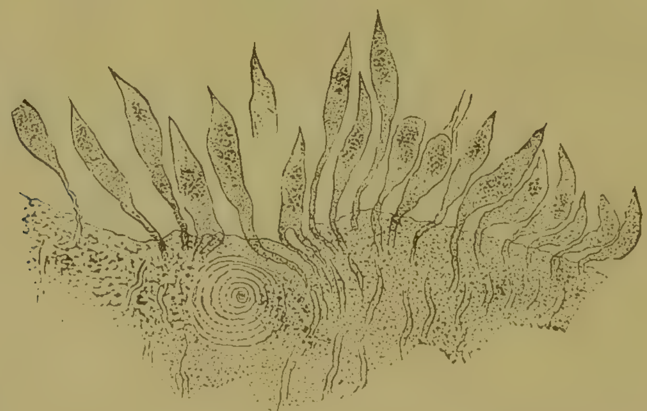
The tubuli located in the crown of the tooth and radiating toward the coronal surface differ slightly from those which occupy the root, in being larger and in not branching until near their termination underneath the enamel.

The tubes anastomose quite frequently with each other, or by curving upon themselves form little loops. Branches have also been discovered crossing the border-line of the dentine into the enamel or cement. This unusual extension is sometimes recognized in the crown or root, and it has been suggested that in such cases the condition has rather a pathological than a physiological significance.

In teeth in which vices of conformation exist (deficiency in quantity and quality of enamel and dentine) the terminal branches of the tubes appear to be lost in minute cavities which are found near the peripheral border of the dentine.

The contents of the tubuli have always been a subject of interest and of varying views, and, while there is still some difference of opinion regarding their function and influence, it is a well-accepted theory that protoplasmic masses occupy them, and that they are instrumental in conveying nutrition and sensation throughout the structure permeated by them. Charles S. Tomes and others have demonstrated to their satisfaction that fibrils occupy and extend from the pulp to the peripheral

Fig. 278.



Odontoblasts clinging to a Fragment of Imperfectly-developed Dentine. The tissue was pulled away in mounting the section. The cells are drawn just as they lay distorted in the mounting, but a good idea is given of their true form (glycerin mounting, $\frac{1}{8}$ inch obj.—Black).

termination of the tubes. The recognition or acceptance of this theory does not, however, in the least disprove or interfere with the hypothesis that the tubuli are a medium for the circulation of the colorless fluid from the blood.

The dentinal fibrils are a soft, gelatinous mass, and from their structure there is nothing to obstruct the slow passage of fluids through them or by their side; and if it is true that in advancing years these fibrils become calcified, resulting in the solidification of the tubuli, then the

only source for this hardening material must be from the pulp and by or through these tubes.

The calibre of the tubes varies from the $\frac{1}{10000}$ to $\frac{3}{10000}$ of an inch in diameter, being, as has been already stated, largest at their openings on the pulp-cavity. By chemical analysis Von Bibra gives the following for perfectly dried dentine:

Organic matters	28.01
Inorganic matters	71.99
	100.00

Calcium phosphate and fluoride	66.72
Calcium carbonate	3.36
Magnesium phosphate	1.18
Other salts	0.73
Organic matter (tooth-cartilage)	27.61
Fat	0.40
	100.00

THE TOOTH-PULP OR THE DENTAL PULP.—This vascular tissue is located in what is termed the pulp-chamber or pulp-cavity (Fig. 266, *c*). It is surrounded by an unbroken wall of dentine (when in normal condition), save the opening at the terminal end of the root (apical foramen), this affording transit for the nerves and blood-vessels which connect it with the arterial and nervous system. It is the formative organ of the tooth, and consequently passes through various progressive stages before it becomes fixed in its anatomical character. It is the source of the vascular and nervous supply from which the dentine derives and maintains its vitality.

The body of the pulp (Fig. 279) consists of a reticulum of delicately branched connective-tissue corpuscles, with a proportionally large and distinct round or oval nucleus and a small amount of cell-body, except that which constitutes the branched processes. Among these processes are found a limited number of lymphoid corpuscles and connective-tissue fibres, though these are not abundant, Charles S. Tomes says, until the period of degeneration has commenced.

Upon the external surface of the pulp, and in contact with the calcified and calcifying tissue—dentine—is placed a double layer of fusiform cells, with prolongations or branched columnar processes (Fig. 279, *b*). According to Klein, the inner layer of these cells extends some of its processes into the body of the pulp; and while it has not, to the writer's knowledge, been demonstrated, the probability is that it is the terminal ends of these that give rise to the nodules in the pulp. Shorter projections unite the cells of the row with each other, and the more slender and longer ones appear to project between the cells of the external layer and hold connection with, or rather pass into, the canals or tubules of the formed dentine. These attenuated and extended processes are apparently tough and elastic, and, passing into the tubuli of the dentine, are recognized as the dentinal fibres of Tomes.

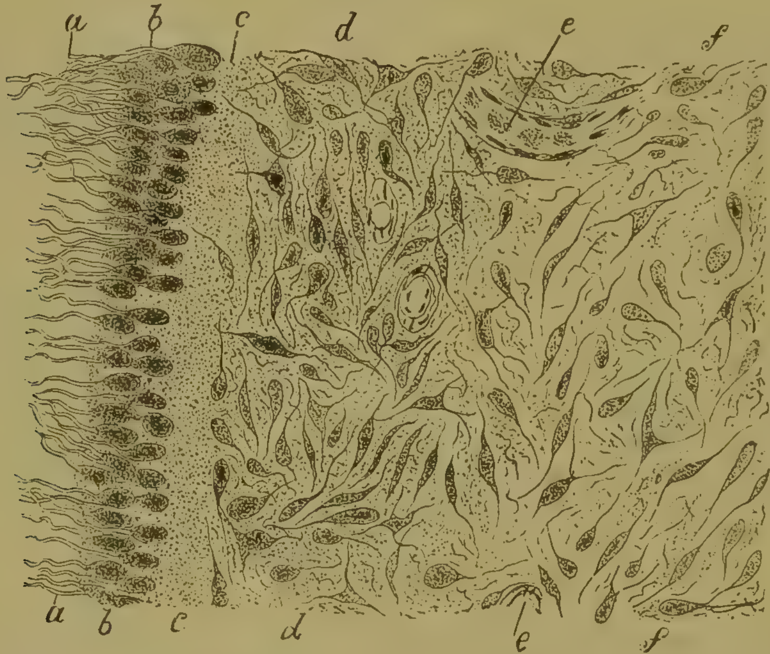
The arrangement of the cellular elements of the pulp is in a direction radiating outward from the centre: this is most prominently conspicuous in the more specialized layer of cells which form the surface of the

pulp and are termed odontoblasts. It is this layer which is spoken of as the *membrana eboris*, because of its adhesion to the wall of dentine, instead of to the pulp, when the parts are torn asunder or lacerated.

Having passed through the various progressive developmental stages, these peculiarly stellated cells are arranged for their final function—viz. that of contributing to the formation of dentine.

The general course of the largest of these fibres is nearly straight (slightly wavy), and almost at right angles or perpendicular to the surface of the dentine. Their attachment to the surface of the dentine can

FIG. 279.



Section of Dental Pulp, near its margin or periphery: *a*, *a*, dentinal fibrils pulled out of the dentine; *b*, *b*, membrana eboris or layer of odontoblasts; *c*, *c*, transparent zone between the odontoblasts and the cells of the pulp proper; *d*, *d*, layer of cells closely packed together; *e*, *e*, blood-vessels; *f*, *f*, cells less closely placed toward the central portions of the pulp (Wales's immersion, $\frac{1}{10}$ inch objective.—Black).

easily be demonstrated by crushing in a vise a recently-extracted vital tooth, when the several fractured pieces will be held quite firmly together by the attachment of these attenuated fibres. The anastomosis of the lateral terminal branches of the fibres of the odontoblasts frequently occurs, presenting the appearance of small lacunæ; and if calcification of these subsequently takes place, they may give rise to the interglobular spaces of Tomes.

According to some investigators, the dentinal fibre is surrounded by a thin, structureless membrane, the dental sheath of Neuman, its calcification forming the tubuli.

In a normal tooth the function of the pulp is the nourishment of the dentine, which is done not only through the tubuli of this structure, but also by a reticulum which pervades the whole dentine tissue. This latter source of sensation and nutrition through the dentine Klein and Heitzman claim to have demonstrated. The diseases of the pulp are the various grades of inflammation with their results, extending from simple vascular excitement to suppuration and death: these are all

more or less complicated in diagnosis and treatment in consequence of its location within a dense, unyielding cavity.

The blood-vessels of the pulp are very numerous. Several arteries, entering at the apical foramen, break up into branches, which at first run parallel with the vertical axis of the pulp, but finally divide into capillaries and form a plexus beneath the odontoblastic layers or cells of the membrana eboris.

Fig. 280.

Point of the Pulp of an Incisor injected with Beale's blue, to show the blood-vessels (× 25). The diagram beautifully illustrates the network of capillaries near the periphery of the organ and just beneath the odontoblasts. The veins are a little larger than the arteries, and anastomose very freely with each other. The arteries have a circular and a longitudinal layer of muscular fibres, but these are very thinly distributed (Black).

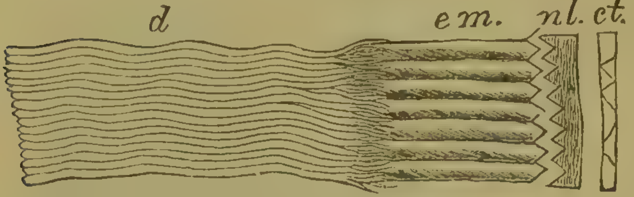
The nerves of the pulp enter through the apical foramen, and consist usually of a larger trunk and three or four minute ones. After pursuing a parallel course, giving off some branches in the expanded portion of the pulp, Mr. Tomes says they form a rich plexus beneath the membrana eboris. The termination or ultimate destination of the primitive fibrils, which are abundant near the surface of the pulp, is a matter of considerable conjecture. Boll thought he had seen them passing through the membrana eboris and taking a direction parallel to that of the dentinal fibres, and hence enter with these fibres the canals of the dentine; but these views have not been confirmed by subsequent investigators. In comparing the views of different authors it is doubtful if any true nerve-fibril has ever been seen to enter the dentine: nothing but the dentinal fibril or prolongation from the inner odontoblastic layer has ever been proved to pass from the pulp into the hard substance of the tooth. This view of the subject would be quite consistent with the practical knowledge we possess of the responsive nature of the dentine tissue to local mechanical and chemical injuries, and also to the influence sedatives and escharotics have upon the exalted sensibility here frequently manifested.

Enamel.—A vertical section of a tooth, as seen in Fig. 266, displays the enamel as an inverted cup-shaped cap covering the dentine, varying in thickness as located on the cutting edge or coronal cusps and on the sides of the crown, the thinnest layers being where it approaches the neck of the tooth and comes in contact with the cementum covering the root, and the thickest on the cusps or edges of the teeth. It is the most dense of all tissues found in the animal economy, and is built up of hexagonal or six-sided fibres or cells, the shape and arrangement of these being essential to secure its density.

The morphology and position of the enamel-fibres are much more readily observed in a recently-developed or in an imperfectly-developed structure than in the well-formed tooth of an adult.

The enamel-fibres are arranged side by side, with their ends upon the surface of the dentine, and maintain almost a vertical or right-angled position with reference to the periphery of this tissue. A vertical section of a tooth gives a very good representation of their compact arrangement, as they cover the outer wall of the subjacent tissue, following the depressions and convexities as they may exist in the crown of the tooth. In the depressions or sulci of the molars, in their effort to cover and protect the dentine, they are often short and irregularly placed, seeming sometimes to be crowded and quite broken in their course.

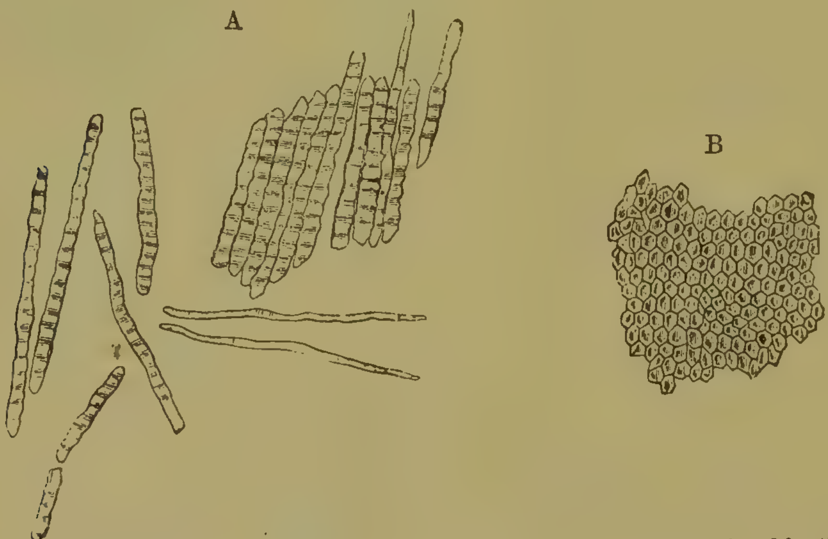
Fig. 281.



Diagrammatic Section of Enamel and Dentine: *d*, dentine; *em*, enamel-prisms; *nl*, nacreous layer: *ct*, cuticula dentis. In the nacreous or cortical layer we have a structure analogous in formation and character to the internal or nacreous layer found in shells (Sudduth).

While the external surface of the enamel presents to the unaided vision a dense, highly-burnished, and apparently homogeneous structure, it is on closer inspection found to be finely striated, the course of these striæ being transverse to the vertical axis of the crown, as well as to the individual fibre, as seen in Fig. 282.

Fig. 282.



Enamel-prisms (350 diameters): A, fragments and single fibres of the enamel isolated by the action of hydrochloric acid; B, surface of a small fragment of enamel, showing the hexagonal ends of the fibres (Sudduth).

In addition to these horizontal lines, others (for which these must not be mistaken) are often seen, far more pronounced in character, resulting from imperfect or arrested development, hence pathological rather than physiological. From the undulating surface of the dentine the fibres in their course often decussate, forming a pattern of squares or diamonds.

Regarding the persistence of an investing membrane or sheath surrounding each original fibre there is much diversity of opinion. Drs. Black, Sudduth, and Williams, also C. S. Tomes, assert that in perfectly healthy human enamel the fibrillar arrangement is not very strongly marked—that the prisms are solid and apparently in absolute con-

tact, without any evidence of an intervening substance. Bödecker, Heitzman, and others contend that enamel is built up of columns of calcified substance, between which minute spaces exist, not only primarily, but are maintained, somewhat analogous to the cement-substance of an epithelial formation. From this intervening material, processes are thrown off which penetrate the enamel-fibres, forming a network of protoplasm. This mass of organic matter permeating the enamel, it is held, has some connection with the plasmic contents of the dentinal tubes through the medium of the apparently cellular structure found occupying the zonal margins between the enamel and dentine. These conclusions are based upon the examination of microscopical sections in which this assumed protoplasmic material has been stained with chloride of gold.

Klein, in his *Histology*, p. 186, says: "The enamel-cells being prismatic, the enamel-matrix is accordingly also composed of prismatic elements—the above enamel-prisms. The increments of the enamel-cells and the conversion into enamel probably occur successively, and hence the aforesaid transverse markings of the enamel-prisms receive their ready explanation. The enamel-cells, like all epithelial cells, being separated from one another by a homogeneous interstitial substance, it is clear that the remains of this substance must occur also between the enamel-prisms. In the enamel of a developing tooth this interstitial substance is larger in amount than in the fully-formed organ. It is improbable that nucleated protoplasmic masses are contained in the interstitial substance of the enamel of a fully-formed tooth, as is maintained quite recently by Bödecker."

The fact that tells most strongly against the presence of this reticulum of protoplasmic material in the enamel of well-developed teeth in the human adult is the almost entire inability to demonstrate its presence by the chemical analysis of the enamel of such teeth, 2 or 3 per cent. of organic matter being the extreme limit of all that is found.

That the enamel-fibre is not entirely homogeneous is, however, readily demonstrated by the action of acids upon it, the central axis yielding much more readily to its influence than does the periphery.

In the calcification of these cells it is the periphery which is first impregnated with the salts of lime, and the central axis is the last to become hard. The action of the acid in its retrograde metamorphic work reverses this.

There has also been noted a striation upon a larger scale than the above mentioned, consisting of brownish lines and known as the "brown striæ of Retzius." They are represented by parallel lines found usually near the coronal extremity. Pigment-cells are found in the enamel of some individuals, but they are by no means universal: they are spoken of by some authors as being layers of cementum, but a critical examination of them soon disproves this idea.

Vices of conformation and deficiencies in the quantity and quality of enamel are not unfrequently manifested by irregularly-formed spaces or cavities located near the border of dentine, and in some cases probably communicate with the tubes of the latter. Bödecker alludes to them as being filled with protoplasm, though of this there is much

doubt, unless in exceptional cases: they are, however, pathological in their significance, and their influence would be as a predisposing cause of dental caries.

Von Bibra gives the following analysis of the enamel from a tooth of an adult man:

Calcium phosphate and fluoride	89.82
Calcium carbonate	4.37
Magnesium phosphate	1.34
Other salts	0.88
Cartilage	3.39
Fat	0.20
	100.00

Organic matter	3.59
Inorganic matter	96.41
	100.00

For much of the material in the foregoing pages the writer is greatly indebted to the observations of Tomes, Allen, Klein, and Black, and especially to the last-named investigator does he again desire to express obligations for extracts from his papers on the periosteum and peridental membrane lately published in the *Chicago Dental Review.*

PART V.

MATERIA MEDICA AND THERAPEUTICS.

MATERIA MEDICA AND THERAPEUTICS.

By HENRY LEFFMANN, M. D., D. D. S.[1]

Materia medica is that branch of medical science which treats of the methods and substances used as remedies in disease.

Therapeutics is the science of the application of remedies and of their effects.

Remedies may be of various kinds, mechanical, hygienic, and pharmaceutical. This section will be chiefly limited to a description of the pharmaceutical preparations and chemical substances having therapeutic value. The classification of remedies is extremely difficult, but the most scientific is that based on their action on the principal functions. One group includes those bodies whose primary or principal effect is on the functions of the nervous system, either depressing or exalting it, and affecting either specially the cerebrum or the spinal and sympathetic systems. Another class of remedies promotes the production of tissue, assisting the functions of digestion or assimilation, or, on the other hand, diminishes the production of tissue or causes increased waste.

Another class, acting through the nervous system, but without markedly influencing its general function, stimulates the action of some gland or organ, and causes some evacuation from the body. In this group are also included a few remedies which act locally.

An important group is that of the substances which prevent septic decomposition and germ-growth. These agents undoubtedly have a growing practical relation to dental science, since some of the diseases of tooth-structure are intimately connected with the development of micro-organisms.

Lastly, we have a class of remedies strictly local in their effects, acting only on the part to which they are applied, and not acting by absorption into the circulation. From these considerations, as presented by Bartholow, we have six classes of remedies:

Those modifying the functions of the nervous system;

Those promoting constructive metamorphosis;

Those promoting destructive metamorphosis;

Those causing some evacuation from the body;

Those preventing septic decomposition and growth of micro-organisms;

Those acting locally only.

[1] The author desires to state that in the preparation of this paper he has been largely assisted by Dr. Litch, who has contributed much of the text relating to the effects and uses of the various remedial agents herein considered.

Administration of Medicines.

The effects of medicines on the system at large are almost always due to absorption into the blood-current, and various methods of introducing them are resorted to. The most usual method is by the digestive organs. When the stomach is empty the absorption, especially of crystallizable remedies, takes place with great rapidity, and a considerable number of bodies which are nearly insoluble in water—*e. g.* calomel and arsenic—are taken up easily by the stomach. The rectal mucous membrane absorbs some remedies, especially the alkaloids, more rapidly than the stomach. Vapors and finely-divided (atomized) fluids or solids are absorbed by the mucous membrane of the air-passages.

Hypodermic Medication.—This now favorite method for securing the rapid action of remedies depends upon the active absorptive power of the lymphatics and capillaries of the subcutaneous cellular tissue. It is necessary that the remedy should go *beneath* the skin, not between its layers, and that it should not enter any large vessel. Localities for hypodermic injection are those free from nerves or large vessels, such as the back, deltoid region, calf of the leg, and exterior aspect of the thigh—just in front of the trochanter. The most convenient form for hypodermic doses is the tablets which are now manufactured with great accuracy. They are to be dissolved in pure water when needed.

Various other methods of introducing medicine are occasionally employed, such as direct application to the skin with or without friction (epidermic method), application to a blistered surface (endermic method), and inoculation by directly introducing the remedy into the blood-current. This latter method is almost entirely limited to vaccination.

Remedies Employed to Modify the Functions of the Nervous System.

In this group are included a variety of remedies which are classified under sub-groups according to the character of the effects produced and the portion of the nervous system affected.

Exciting functional activity:
- *a*, Of the spinal cord and sympathetic;
- *b*, Of the cerebrum.

Diminishing functional activity:
- *c*, Of the spinal cord and sympathetic;
- *d*, Of the cerebrum after a preliminary stage of excitement.

(*a*) Agents Exciting Functional Activity of the Spinal Cord and Sympathetic.

Electricity.

Several forms of electrical excitement are recognized, which, although of substantially the same nature and convertible one into the other, are different in their physical, chemical, and physiological effects.

Static Electricity.—This term is generally applied to that produced by friction. It has lately been prominently brought forward as

a therapeutic agent, and machines operating, not by friction, but by inductive effect from a surface previously excited by friction, are used. The effects of this form are either received directly by sparks or by charging the body while it is placed on non-conducting supports.

MAGNETISM is a sort of static charge which many bodies are capable of assuming either under the influence of an electric current or by contact. Most bodies lose their magnetic condition when removed from the electrical influence, but steel retains it after being once impressed, and constitutes what is known as a *permanent magnet*. Wrought iron retains magnetism only so long as it is under the electrical influence, and thus furnishes the means of producing temporary or *electro-magnets*. Contact of a permanent magnet with pieces of iron or steel will develop magnetism in them.

GALVANISM.—This is the electricity produced by chemical action. The principle of its production is a wide one, and may be stated, generally, to be, that when two bodies capable of conducting electricity are immersed in a substance which acts *unequally* on them and is also capable of conducting electricity, an electrical disturbance results. The available current moves from the body more acted on to the one less acted on, and returns to the first one through any intermediate substance capable of conducting it. This constitutes a *circuit*. On this general principle many forms have been designed. They are called *batteries* or *cells*. They generally contain two metals, or a metal and carbon, immersed in liquids. The metals used are called the *elements* of the battery; the terminals of the elements are the *poles*; the liquid in which they are immersed is known as the *electrolyte*. The poles are called *anode* (or positive), written An, and *kathode* (or negative), written Ka. The anode is the terminal of the element less acted on (carbon, copper, platinum, or silver); the kathode, of the element more acted on (zinc or iron).

One of the most frequent forms of batteries consists of plates or cylinders of zinc, the surface of which has been covered with a layer of mercury (amalgamated), and a plate of carbon, each immersed in an acid liquid, separated by porous partitions, so that the mingling may be slow. The essential reaction is the solution of the zinc in the acid liquid with which it is in contact, generally dilute sulphuric acid, and the liberation of hydrogen; *e.g.* $Zn + H_2SO_4 = ZnSO_4 + H_2$.

This hydrogen would escape at the surface of the other elements of the battery, and constitute an interfering condition, to prevent which oxidizing agents (nitric acid or chromic acid) are generally used. Thus, the form known as Bunsen's battery consists of a glass jar filled with dilute sulphuric acid and containing a cylinder of zinc, inside of which is a jar of unglazed earthenware (porous cup). In this is placed a rod of carbon and a strong solution of potassium bichromate and sulphuric acid, which produces chromic acid. The hydrogen, which would otherwise be liberated, is consumed by the chromic acid. Occasionally, the porous cup is omitted, and the zinc and carbon both allowed to dip into the chromic-acid solution (Grenet cell). This gives more rapid action, and hence more powerful currents, but the cell is soon exhausted.

By substituting a piece of copper and solution of copper sulphate for the carbon and chromic acid in the porous cell of the Bunsen battery, a cell of less energy but considerable constancy, known as *Daniell's cell*, is obtained. The porous cell in this form may be avoided by placing the copper and a dense solution of copper sulphate at the bottom of the jar, and the zinc and acid above, allowing gravity to prevent too rapid diffusion. These are now much used under the name of "gravity" batteries.

The force generated by a battery is called *electro-motive force*, and depends on the nature of the elements and the electrolyte. The electrical charge from any battery will flow through a *circuit*—that is, through conducting substances which form a continuous chain from the anode to the kathode. Unless the number of cells be considerable, the current will not pass over a small space of non-conductor, such as a break in the circuit.

If the current be caused to move in a spiral or helix around a piece of wrought iron, the iron will become a magnet, constituting an electro-magnet; and, further, the current itself is capable of *inducing* a current in an adjoining wire, the two wires not being in any way connected. This is known as *faradic* or *induced* electricity, and is, as a rule, more intense than the original current.

For the proper study of electricity a series of precise terms have been devised:

A *Volt* is the unit of electro-motive force, and is nearly equal to the power of a Daniell's cell.

An *Ohm* is the unit of resistance—that is, of the obstruction offered to a current by the substance through which it is flowing.

An *Ampère* is the unit of intensity, and represents the quantity of electricity furnished by a Daniell cell and made to pass through 111 yards (100 meters) of telegraph wire.

A *Farad* is the unit of capacity.

By the rapid rotation of a coil of wire containing cores of wrought iron before permanent magnets, powerful currents of electricity may be generated. Such machines are called "dynamos," and are used for electric lighting and heating. By reversing the arrangement and leading a current into the coils of wire, a rotation is caused, and upon this principle is based the electric motors used for drills and pluggers.

By passing the current of a battery or dynamo through a helix of short, thick wire, around which is wrapped without metallic contact a long coil of fine wire, it is found that every time a current of electricity is passed into the thick wire a momentary rather powerful shock is felt in the outer wire, and that no further effect ensues until the current is shut off, when a second shock occurs in the outer wire. The arrangement is known as an induction coil. This is the principle upon which all the ordinary medical coils are constructed.

Physiological Action of Electricity.—Electricity stimulates muscular action, either when applied directly or through the nerves supplying the muscles. The action occurs only at the opening or closing of the circuit. If the opening and closing are slow, the muscle has time to relax; if the circuit is altered very rapidly, the muscles

are tetanized, but will be ultimately fatigued, and then relax. The reactions with muscles depend on the manner in which the poles are arranged with reference to the muscles. An elaborate system has been developed of recent years, the method being used, among other purposes, for determining, by the manner in which the muscle or its nerve responds to stimulation, the extent and nature of various affections of the central nervous system. The normal responses to a current of a given character and intensity become in disease either diminished or reversed.

Currents of galvanic or "dynamo" electricity have to a noticeable degree the power of producing chemical decomposition or electrolysis, and have been used to promote decomposition of morbid growths. Powerful currents cause great and even fatal prostration.

THERAPEUTICS.—Electricity in its various forms has been extensively applied in medicine. In some cases its action is confessedly due to the mental impression. Galvanic electricity is the form most generally employed, the class of cases treated including almost all forms of disease in the brain or nervous system. In various forms of paralysis, neuralgia, spasmodic affections, even in affections not directly nervous, such as anæmia, dyspepsia, chlorosis, rheumatism, electricity is employed. It is also of great value as a stimulant in cases of suspended animation.

GALVANO-CAUTERY.—When a current of electricity is passed through a resisting body, such as a fine wire, it is converted into heat. We have in this fact a means of heating a wire to a red or white heat, and of maintaining it thus so long as the current passes. A platinum wire loop is usually employed. The wire is used not very highly heated, and it cuts through the tissue without causing much bleeding.

Recent improvements in incandescent lighting have led to the construction of portable electric lamps of size suitable for illumination of the mouth, enabling the operator to examine under full light the cavities and surfaces of teeth and determine very accurately the condition of the pulp. By placing the light within the mouth and against any portion of the buccal surface or surface of the lips, the patient being in a dark room, the existence of pus or other deposit can be detected by the opacity which is produced as contrasted with the ruddy translucency of the healthy tissue. The employment of electricity as an anæsthetic is referred to on p. 212.

CARE OF ELECTRICAL APPARATUS.—Apparatus used in producing or applying static electricity should be kept dry and free from dust. The portions intended to convey the charge must be well insulated, except at the point at which the charge is to pass. Apparatus for producing or applying galvanic electricity should be kept clean. All points of connection, binding-screws or other junctions, should be kept bright, and firm pressure used in making junctions. The liquids in batteries must be replaced as they evaporate or become neutralized. The ordinary oxidizing mixture of potassium bichromate and sulphuric acid is fit for use only so long as it retains a red color. When it becomes brown or green it is exhausted. Batteries in which this liquid is used must not be allowed to become dry, as the solution will form large, hard crystals which will break the carbon plate and porous cell. Nitric and

other acids which give off corrosive fumes are entirely unsuitable for batteries for office use.

The wires employed for battery connection may with advantage be curled in helixes. Covered wire is best, and the ends should be clean and bright. All zinc plates for batteries should be coated with a film of mercury (amalgamated) by dipping them in dilute sulphuric or hydrochloric acid, washing with water, and spreading a small quantity of mercury over the surface.

Care should be taken not to allow crystalline crusts to develop around the terminals of the battery-plates, as short circuits may be thus formed, detracting much from the general current. In a series of cells the size, arrangement, and level of the liquid should be uniform.

In the induction apparatus, motors, faradic coils, etc. the connections must be kept clean, and especially the automatic break-piece, which requires careful adjustment.

Nux Vomica.—Nux vomica is the seed of the *Strychnos nux vomica*. It contains at least two alkaloids, *strychnine* and *brucine*, to the former of which the effects of the drug are mainly due.

PREPARATIONS:

Abstractum nucis vomicæ: dose, gr. $\frac{1}{2}$.
Extractum nucis vomicæ: dose, gr. $\frac{1}{8}$ to $\frac{1}{2}$.
Extractum nucis vomicæ fluidum: dose, ♏j–v.
Tinctura nucis vomicæ: dose, ♏v–x.
Strychnina (strychnine, $C_{21}H_{22}N_2O_2$), the principal alkaloid, is a crystalline, highly bitter substance, scarcely soluble in water: dose, gr. $\frac{1}{60}$ to $\frac{1}{20}$.
Strychninæ sulphas is a crystalline salt soluble in water and alcohol: dose, gr. $\frac{1}{60}$ to $\frac{1}{20}$.
Brucine is not official: dose, gr. $\frac{1}{10}$ to $\frac{1}{3}$.

PHYSIOLOGICAL ACTION.—In small doses strychnine acts as a bitter tonic, increases the gastro-intestinal secretions and intestinal peristalsis, and raises arterial tension. In larger doses the pupils are dilated, the muscles are spasmodically contracted. A poisonous dose, above $\frac{3}{4}$ grain in an adult, produces muscular tremors, exaggerated reflexes, and intermittent tetanic spasms, resulting, ultimately, in death from the rigidity of the respiratory muscles. The mind is not affected. Strychnine is excreted very slowly, hence poisonous amounts may accumulate in the system from small doses frequently repeated.

The antidotes are free evacuation of the stomach, vegetable astringents, which precipitate the strychnine, chloroform or ether inhalation, and chloral hypodermically.

THERAPEUTICS.—Nux vomica and strychnine are used as stomachic and muscular tonics. It is best to use an accurate preparation of the alkaloid. It is used in atonic dyspepsia, in constipation, and in anæmia. Local paralyses are treated by hypodermic injections into the affected muscles. It is also used in the treatment of various eye affections and neuralgias. It is a physiological antagonistic to chloral, physostigmine, and morphine, and may be used in poisoning by these substances.

Brucine has generally been regarded as similar to strychnine, but much weaker. Observations made lately by Dr. Thos. J. Mays of Philadelphia have shown that samples of brucine are generally contaminated with strychnine, and that the pure alkaloid possesses prop-

erties analogous to cocaine, including its local anæsthetic power. The question will therefore need further investigation.

Ignatia (St. Ignatius's Bean) is the seed of the *Strychnos Ignatii*, also called *Ignatia amara*. It contains strychnine and brucine, the former in larger quantity than in nux vomica. Its effects and uses are the same as those of nux vomica, but it is rather more powerful.

Picrotoxin ($C_9H_{10}O_4$) is a neutral principle from the berries (*Cocculus Indicus*) of the *Anamirta paniculata*, an East Indian plant. It forms white bitter crystals slightly soluble in water: dose, gr. $\frac{1}{60}$ to $\frac{1}{30}$.

Physiological Action.—Picrotoxin is a cerebro-spinal stimulant; it increases all the secretions and causes nausea and vomiting. It produces choreic spasms, chiefly in the flexor muscles. The berries have been used to render malt liquors more intoxicating.

Chloral antagonizes the cerebral spinal effects of picrotoxin, and anæsthetics control the spasmodic action.

Therapeutics.—Picrotoxin is used in the treatment of epilepsy and various paralytic affections; also in night-sweats, colic, and painful dyspepsia.

Ergota (Ergot).—Ergot is a fungous growth in a special stage of development, replacing the seed of common rye. Its composition is somewhat complex, and is not well made out: dose, gr. x–ʒj.

Preparations:

Extractum ergotæ fluidum: this is a good form for internal use: dose, fʒss–ij.
Extractum ergotæ, often called *ergotin:* dose, gr. ij–xv.
Vinum ergotæ: dose, fʒj–f℥j.

Physiological Action.—Ergot produces strong contraction of involuntary muscular fibre; it therefore contracts the smaller blood-vessels and the uterus. Its effect depends on the dose. In large doses it is a gastro-intestinal irritant; it also dilates the pupils and produces headache. After very large doses—several ounces of the drug—convulsions may follow. In small doses, repeated for a long time, tetanoid spasms are produced, ending in death by coma or asphyxia, or in other cases its prolonged use is followed by gangrene of the lower extremities.

Therapeutics.—Ergot is largely used to produce uterine contraction in childbirth. It is employed in dysentery, diarrhœa, atonic arterial hemorrhages, cerebral hyperæmia, spinal congestion, and paralysis of the sphincters. In diabetes, especially the form not attended by the excretion of sugar, it is much used. The aqueous extract, dissolved in water, is preferred for hypodermic use: dose, gr. $\frac{1}{4}$–iij. Amyl nitrite, aconite, veratrum viride, and tobacco are antagonistic. As it contracts the arterioles, it may be found useful in the treatment of hemorrhagic conditions of the gums and is of service in persistent hemorrhage after tooth-extraction.

Digitalis (Foxglove).—Digitalis is the leaves of the *Digitalis purpurea*. The active principle is not definitely ascertained. An amorphous substance, called *digitalin*, is obtained from the leaves, but it does not exactly represent the drug.

PREPARATIONS:

Abstractum digitalis: dose, gr. $\frac{1}{4}$–j.
Extractum digitalis: dose, gr. $\frac{1}{6}$–$\frac{1}{2}$.
Extractum digitalis fluidum: dose, ♏j–iij.
Tinctura digitalis: dose, ♏v–f℥ss.
Infusum digitalis: dose, f℥ss.

PHYSIOLOGICAL ACTION.—Digitalis is a cardiac stimulant. It diminishes the rate but increases the force of the heart movements, prolonging the diastole and intensifying the systole. During the use of the drug the recumbent position should be maintained, as the motor power of the heart is exhausted by over-stimulation, and its energy may suddenly fail. This causes the apparent cumulative effect. Digitalis is irritant to the gastro-intestinal tract, often producing violent vomiting and purging—an effect best counteracted by giving it in combination with aromatics as in the official infusion, which contains cinnamon and is the best preparation. It produces an increased flow of urine, partly by increased blood-pressure and partly by specific stimulation of the Malpighian tufts. During its administration the temperature is lowered. Vegetable astringents and iron salts are incompatible with digitalis; aconite is antagonistic.

THERAPEUTICS.—Digitalis is principally used in heart troubles, especially in dilatation of the right heart, with incompetence of the tricuspid valve. It is useful in cardiac and renal dropsy and congested conditions of the brain. Its value depends upon its power to restore the normal balance of the circulation, relieving the venous system from engorgement by giving time for the auricles to empty into the ventricles and thus fill the arteries with their proportionate share of blood. It is not used in simple compensatory hypertrophy of the heart or in fatty heart. Owing to its power of producing arterial contraction, digitalis may be usefully employed as a hæmostatic in the hemorrhagic diathesis or in traumatic hemorrhages.

Convallaria, the herb of the *Convallaria majalis*, lily-of-the-valley, is as yet unofficial; it has attracted attention as being an analogue of digitalis, but less dangerous in its action. It has also been known as a diuretic and cathartic. An extract is used in doses of gr. v–xx. Also a fluid extract: dose, f℥ss–j.

The physiological action and therapeutics are similar to those of the digitalis.

Cimicifuga (black snake-root) is the rhizome of the *Cimicifuga racemosa*. It contains a volatile oil and an acrid crystalline principle.

PREPARATIONS:

Extractum cimicifugæ fluidum: dose, ♏x–f℥j.
Tinctura cimicifugæ: dose, f℥ss–ij.

PHYSIOLOGICAL ACTION AND THERAPEUTICS.—Cimicifuga is diuretic, diaphoretic and expectorant. In its action on the heart it is similar to digitalis, slowing its contractions, but increasing their force and raising arterial tension. On involuntary muscular fibre it is analogous to ergot. It is considered safer than digitalis, especially in weak or fatty heart. It is used as a tonic and expectorant, and also in localized muscular rheumatism and in uterine disorders.

Belladonna.—*Belladonna folia* (belladonna-leaves) and *belladonna radix* (belladonna-root) are the official portions of the herb *Atropa belladonna* (deadly nightshade). The medicinal value depends substantially upon an alkaloid, atropine (*atropina*). It forms a sulphate which is official, *atropinæ sulphas*, $(C_{17}H_{23}NO_3)_2H_2SO_4$.

PREPARATIONS:

Tinctura belladonnæ, from the leaves: dose, ♏j–ʒss.
Extractum belladonnæ alcoholicum, from the leaves: dose, gr. $\frac{1}{10}$–$\frac{1}{2}$.
Extractum belladonnæ fluidum, from the root: dose, ♏j to v.
Abstractum belladonnæ, from the root: gr. $\frac{1}{8}$–$\frac{1}{2}$.
Unguentum belladonnæ, from the leaves.
Emplastrum belladonnæ.
Linimentum belladonnæ.

Atropinæ sulphas, atropine sulphate, is a white powder soluble in water. It is generally used for external application. The dose of atropine sulphate is not over $\frac{1}{60}$ of a grain, and generally less, even $\frac{1}{120}$. In the latter doses it is often used hypodermically.

PHYSIOLOGICAL ACTION.—Belladonna is an irritant narcotic, and paralyzes the motor nerves and diminishes the sensibility of the sensory nerves: in large doses it stimulates the brain, producing disturbed consciousness and delirium. Its effects can be produced by direct absorption from the skin and mucous membrane. Applied locally, and even when taken internally, it produces dryness of the mucous membrane, especially of the mouth and throat, and an eruption somewhat resembling that of scarlet fever appears. Perspiration is lessened. When the dose is very large, swallowing may become so difficult as to give rise to convulsions, these being followed by paralysis, stupor, coma, and death from asphyxia. The temperature is temporarily increased by medicinal doses. The pulse-rate is increased; respiration is at first quickened, then retarded. It at first diminishes, but finally increases greatly, the gastro-intestinal secretions. Small doses increase the movements of the intestines.

One of the most striking symptoms of the action of belladonna is the dilatation of the pupil, the eye becoming bright and injected. A very minute quantity of atropine will produce this effect. In general terms it may be stated that the effects of atropine are not materially different from those produced by belladonna.

THERAPEUTICS.—Local applications of solutions of atropine are used to relieve pain, but especially to dilate the pupil, paralyze accommodation, and diminish pain in the examination and treatment of the eye. In the form of the belladonna plaster it is much used for the relief of neuralgia, myalgia, or spasm, and an ointment or a liniment is frequently employed for the relief of severe pain, such as that of anal fissure. Internally, it is used to stop the secretion of milk and the excessive secretion of mercurial ptyalism. In habitual constipation relief is sometimes afforded by the use of the extract in doses of about one-quarter of a grain: this preparation is generally an excellent addition to purgatives. In acute inflammation of the air-passages with profuse secretion, and in ordinary sore throat, the tincture of belladonna is strongly recommended by Bartholow, the medication beginning with five drops, to be followed by a drop or two every hour until symptoms of the physiological action appear. In the cases in which the bronchial mucous membrane is dry it is not to be used. It is also recommended in whooping cough. In nocturnal

incontinence of urine, especially in children, it is much employed. In erysipelas of a superficial and non-vesicular character it seems to act like a specific. Hypodermic injections of atropine sulphate, $\frac{1}{80}$ to $\frac{1}{60}$ of a grain, are employed for the relief of the night-sweats of phthisis. It is also used in the treatment of typhoid and typhus fevers, epilepsy, and chorea, but in the latter diseases it is inferior to potassium bromide.

Belladonna is to a certain extent antagonized by opium, and in cases of poisoning the stomach should be emptied by prompt emetics, such as zinc sulphate or copper sulphate, and tincture of opium be given cautiously until some contraction of the pupil, lessening of the pulse-rate, and diminution of delirium occurs. In children opium as an antidote must be used with great care. Conversely, in opium-poisoning belladonna is a physiological antagonist. Atropine sulphate is often combined in minute amount—about $\frac{1}{120}$ of a grain—with morphine sulphate in hypodermic use, the pain-relieving power of the latter agent being thereby increased, while the tendency of belladonna to produce illusions, or even delirium, is diminished. Atropine sulphate is used alone in rather full dose in the treatment of tic douloureux and sciatica, injected at the neighborhood of the affected nerve. In dental practice it has been employed as an anodyne application to exposed and inflamed dental pulps, but in this class of cases it is usually much less effective than are the morphine salts.

Homatropine.—This is a derivative from atropine, similar in its physiological effects and therapeutic uses, except that it retards the heart's action and is unirritating when locally applied; hence its advantage to oculists.

Stramonium.—*Stramonii folia* (stramonium-leaves), *stramonii semen* (stramonium-seeds), are the portions selected from the *Datura stramonium*, a coarse herb now extensively naturalized in this country, and known as Jamestown or "jimson" weed. Its physiological activity is dependent on an alkaloid called daturine, which is generally considered identical with atropine; there is also a small quantity of hyoscyamine present. The physiological effects and therapeutic uses of stramonium are similar to those of belladonna, but it is not so extensively employed, as the delirium it produces is very violent.

The preparations of stramonium are all made from seed.

Extractum stramonii: dose, gr. $\frac{1}{4}$–$\frac{1}{2}$.
Extractum stramonii fluidum: dose, ♏j–iv.
Tinctura stramonii: dose, ♏x–xxx.
Unguentum stramonii.

The dried leaves are sometimes used as antispasmodic cigarettes for asthma, but are not entirely safe in aged or apoplectic persons. The abundance of the herb in the wild state occasionally leads to poisoning. The symptoms are similar to those of belladonna-poisoning, and are to be treated in the same manner.

Hyoscyamus.—Hyoscyamus is the leaves, with attached branches, of the *Hyoscyamus niger*. Its activity depends upon an alkaloid which has the same composition as atropine, but is probably not exactly identical with it. It is similar in its action to the alkaloids of this group

of remedies, but is more hypnotic. The delirium produced by it is less violent, and in general less powerful than that following either belladonna or stramonium.

The preparations are—

Abstractum hyoscyami: dose, gr. iij–v.
Tinctura hyoscyami: dose, f℥j–iv.
Extractum hyoscyami fluidum: dose, ♏v–xx.
Extractum hyoscyami alcoholicum: dose, gr. ½–j.

Hyoscyaminæ sulphas, hyoscyamine sulphate, the active principle in the form of sulphate, chemically identical with atropine sulphate, is official; also a derivative, *hyoscine*, a liquid alkaloid decidedly more powerful than hyoscyamine itself. Hyoscyamine is used in doses of $\frac{1}{40}$ to $\frac{1}{2}$ grain; hypodermically in doses of $\frac{1}{60}$ to $\frac{1}{12}$ of a grain; hyoscine hypodermically in doses of $\frac{1}{100}$ to $\frac{1}{50}$ of a grain. Hyoscine hydrobromate, in doses of from $\frac{1}{120}$ to $\frac{1}{90}$, has been found very efficient in insomnia of acute delirium. Preparations of hyoscyamus are frequently added to cathartic combinations to prevent the griping which is so apt to occur in the action of such remedies. The abstract would probably be adapted to this use.

In poisoning by hyoscyamus the same treatment is to be followed as in cases of poisoning by belladonna.

Duboisia.—The leaves of the *Duboisia myoporoides*, an Australian shrub analogous to belladonna. It contains an alkaloid which is closely allied to atropine. A sulphate of this, duboisine sulphate, is much used by oculists as a substitute for atropine sulphate, because of more prompt action and briefer effect. There are no preparations official as yet in the United States Pharmacopœia, but, in addition to the sulphate of the alkaloid, a tincture, dose v–xx drops, and an extract, dose $\frac{1}{6}$ to $\frac{1}{4}$ grain, are prepared from the leaves. The use of the drug is almost exclusively limited to ophthalmic practice.

(*b*) Agents Exciting Functional Activity of the Cerebrum.

Camphora (Camphor).—Camphor is a solid volatile oil from the *Cinnamomum camphora.* It is volatile, slightly soluble in water, freely in alcohol. Its composition is $C_{10}H_{16}O$.

Preparations:

Aqua camphoræ: dose, f℥j–f℥iv.
Spiritus camphoræ: dose, ♏v–♏xx.
Linimentum camphoræ.
Ceratum camphoræ.
Camphora monobromata, monobromated camphor, $C_{10}H_{15}BrO$, is a derivative used in doses of gr. j–gr. x in emulsion.

Physiological Action.—Camphor is cerebral excitant, antispasmodic, anodyne, antiseptic, rubefacient, and diaphoretic. It stimulates the heart and the vaso-motor system and lessens the influence of the pneumogastric. Monobromated camphor resembles somewhat the bromides in action: it is a sedative and hypnotic. In excessive doses it will diminish the reflex movements of the spinal cord, depress the heart, and may cause death, this being generally preceded by convulsions and

coma. The action of camphor is antagonized by the motor depressants. The alcoholic solutions are precipitated by water, and its watery solution by many salts.

THERAPEUTICS.—Camphor has been long used as an antispasmodic, and also in the treatment of diarrhœas, nervous headache, and febrile affections. It is a familiar ingredient in cholera mixtures. A mixture with carbolic acid, alcohol, and olive oil is used as a dressing for wounds, and without the oil for putrescent tooth-pulps. Monobromated camphor is used in chorea and hysteria.

In dentistry the spirit of camphor is employed as a local anodyne for sensitive dentine and for the pain following extraction of teeth from highly-inflamed alveoli. It is sometimes used for this purpose in strong solution in chloroform (camphor, ℨj; chloroform, fℨij). As a local anæsthetic in tooth-extraction the following has been recommended. Whatever influence it may exert in diminishing pain is probably chiefly due to the rapid vaporization of the ether.

℞. Pulv. camphoræ, ℨvj;
Ætheris, f℥j. M.

S. Apply to the gum over the root of the tooth to be removed, continuing the application until the tissue blanches.

Its chemical relationship to the antiseptics indicates that it has some antiseptic value, and hence its occasional use on putrescent pulps, especially in combination with carbolic acid, equal parts of each being mixed and melted in a sand-bath. (See p. 985, Vol. I.)

The following formula has been recommended as a local application in neuralgia and exposed dental pulps:

Camphor	5 parts;
Chloral hydrate	2 "
Cocaine hydrochlorate	1 "

Heat to about the boiling-point of water till liquefied.

Camphor is one of the ingredients of celluloid. (See Vol. II. p. 735.)

Asafœtida (ASAFETIDA)—Asafetida is a gum-resin derived from the root of *Ferula narthex* and *Ferula scorodosma,* umbelliferous plants growing in Persia. The gum is obtained by exposure and excision of the root. It contains as an active principle allyl sulphide $(C_3H_5)_2S$, in addition to gum and resin. The dose is gr. v–xx.

PREPARATIONS:
- *Mistura asafœtidæ:* dose, f℥ss–ij.
- *Tinctura asafœtidæ:* dose, fℨss–ij.

PHYSIOLOGICAL ACTION AND THERAPEUTICS.—Asafetida is a powerful nervous stimulant and antispasmodic. Its nauseous taste and odor interfere somewhat with its use. It nevertheless, in small amounts, may be used as a flavor for food, and persons become fond of it, as in the case of onions or garlic. It stimulates the secretions.

The mixture of asafetida is used in the treatment of flatulent colic, bronchial affections, hysteria, and flatulent indigestion.

OTHER ANTISPASMODICS.—Several vegetable preparations may be enumerated briefly, the properties and uses of which are substantially similar to those of asafetida:

Ammoniacum.—Ammoniac is the gum-resin from a Persian plant, *Dorema ammoniacum:* dose, gr. x–xxx.

Cypripedium, the rhizome of several species of orchidaceous plants. It is used in the form of a fluid extract: dose, ♏x–xxx.

Galbanum is a gum-resin from a plant closely allied to that which yields asafetida: dose, gr. x–xx, in pills or emulsion.

Scutellaria (SKULL-CAP), the entire plant of the *Scutellaria latifolia.* It is used in the form of a fluid extract: dose, f℥ss–ij.

Valeriana (VALERIAN).—Valerian is the rhizome of the *Valeriana officinalis.* It contains a volatile oil and several oxidized derivatives from it, among which is valeric acid, $HC_5H_9O_2$, to which the odor and virtues of the drug are largely due. Valeric acid is now made artificially from fusel oil, and, although not exactly identical with that obtained from the drug, has largely replaced it.

PREPARATIONS:

Abstractum valerianæ: dose, gr. v–xx.
Extractum valerianæ fluidum: dose, ♏x–xxx.
Tinctura valerianæ: dose, f℥ss–ij.
Tinctura valerianæ ammoniata: dose, f℥ss–ij.
Oleum valerianæ is the volatile oil, a yellowish liquid soluble in alcohol. It is one of the most eligible forms for use: dose, ♏ij–v.

VALERATES.—These, officially called valerianates, are usually made from the artificially prepared acid, and, according to some authorities, are not good substitutes for the preparations from the drug itself. The official valerates are—

Ammonii valerianas, $(NH_4)C_5H_9O_2$: dose, gr. ij–x.
Ferri valerianas, $Fe_2(C_5H_9O_2)_6$ (note that this is a ferric salt): dose, gr. j–iij.
Quininæ valerianas: dose, gr. j–iij.
Zinci valerianas, $Zn(C_5H_9O_2)_2H_2O$: dose, gr. ½–ij.

PHYSIOLOGICAL ACTION.—Valerian is a gentle stimulant and antispasmodic. In full doses it increases the heart's action and raises the temperature. Large doses cause hiccough, diarrhœa, nausea, and vomiting, and produce paralysis of the spinal system. It is antagonistic to strychnine.

THERAPEUTICS.—Valerian is much used in the treatment of hysteria and general nervousness, especially in women. In many cases of the latter character unattended by serious organic disease it probably acts as much by the mental impression as by its physiological quality.

The valerianates are used for the same purposes as the drug. Ammonium valerianate is much used in nervous headache: dose, gr. x. It may be employed for the relief of dental and other neuralgias.

Cannabis (HEMP).—Cannabis is the herb of the *Cannabis sativa.* The hemp-plant grows in various quarters of the world. American hemp (*Cannabis Americana*) is active, but that from India (*Cannabis Indica*) is the more powerful. The active constituent is a resin, *cannabin:* the preparations are variable in strength.

PREPARATIONS:

Extractum cannabis Indicæ: dose, gr. ⅛–j.
Extractum cannabis Indicæ fluidum: dose, ♏j–v.
Tinctura cannabis Indicæ, tincture of hemp: dose, ♏xx–f℥j.

Both the tincture and the fluid extract are liable to be precipitated in mixtures, to prevent which mucilage of gum arabic is employed.

PHYSIOLOGICAL EFFECTS.—Cannabis is antispasmodic, anæsthetic, and narcotic. It increases motor activity and stimulates the intellectual and sexual functions. In large doses it produces a pleasurable delirium, and in the East various preparations are used, such as hasheesh, gunjah, bhang, and churrus, for intoxicants. Deep sleep follows the use of a full dose, but fatal results are said to be rare. The after-effects are headache, loss of sensibility of the skin, and confusion of thought, but neither nausea nor constipation. Strychnine and a faradic current are the physiological antagonistics. In poisoning the stomach should be evacuated and artificial respiration maintained. Lemon-juice may also be used freely, as it is thought to antagonize the drug.

THERAPEUTICS.—Cannabis is now not much used except in special cases. In sick headache and neuralgias it is often effective. It is considered a very good hypnotic in delirium tremens, and is also used in tetanus, and in these disorders is sometimes employed as being safer than opium. It is given for the relief of pain and spasm in affections of the bladder and urethra. In all cases care should be taken not to administer large doses until the quality of the preparation has been tested by cautious administration. An unofficial so-called cannabin tannate has been recommended in five- to ten-grain doses as a powerful and safe hypnotic in acute mania. In dental practice it has been successfully employed, both internally and locally, for the relief of odontalgia from exposed pulp. Christison found that a full dose caused entire cessation of pain from that cause in an hour after its administration.

Erythroxylon (COCA).—Coca is the leaves of the *Erythroxylon coca*, a South American shrub. It is somewhat similar to tea and coffee in character, and has long been used by the Peruvians to diminish the feeling of fatigue. It contains among other ingredients a crystalline alkaloid now very widely known and used under the name *cocaine*. The leaves contain about 0.03 per cent. of this alkaloid.

PREPARATION:

Extractum erythroxyli fluidum: dose, f℥ss ij.

Of recent years the alkaloid cocaine and its hydrochlorate (muriate) have been introduced into practice.

COCAINE ($C_{17}H_{21}NO_4$) forms colorless bitter crystals sparingly insoluble in water: dose, gr. $\frac{1}{8}$–ij.

Cocaine hydrochlorate ($C_{17}H_{21}NO_4HCl$) is the preparation generally used. It is employed in the form of a 4 per cent. solution in water, especially as a local anæsthetic. Dose, internally, gr. $\frac{1}{8}$–ij.

Cocaine oleate, made by dissolving cocaine in oleic acid, is sometimes used externally.

PHYSIOLOGICAL ACTION.—Coca is an aromatic bitter tonic and nervous stimulant, but locally is a sedative. It diminishes the sense of fatigue and hunger. Cocaine has a primary stimulant action on the brain, which is followed by a narcotic effect. The intensity of the action seems to vary with the method of administration. Large doses produce

increased pulse and respiration, contraction of the arterioles, sweating, dry throat, dilated pupils, and wakefulness. The public attention which has been attracted to this body has led to cases of excessive use which appear to result in very extensive physical degeneration and loss of mental power and moral rectitude. There is absence of appetite, impairment of digestion, decay of the teeth, emaciation, insomnia, hallucinations, and often wild delirium. This condition, known as cocainism, is frequently coincident with the formation of habits of the most depraved character.

It is as a local anæsthetic that cocaine is chiefly useful. Applied to mucous surfaces, the conjunctiva, tongue, throat, etc., it produces profound but brief loss of sensibility. Its action extends over a limited area, and is not very marked on the unbroken skin. It appears that a severe local congestion sometimes follows the application.

THERAPEUTICS.—Cocaine is employed in neurasthenia, in melancholia, in some forms of insanity, and in wasting diseases; also in gastralgia. A preparation of coca has been used to relieve hoarseness, and the leaves have also been used in cigarettes for hay fever and irritable throat affections. Cocaine oleate has been used in pruritic skin affections.

Cocaine hydrochlorate is the form generally used for obtaining the local anæsthetic action, a 4 per cent. solution being preferred. The solution is lightly brushed over the surface, and the application repeated in about five minutes if a strong impression is desired. The full effect occurs in about fifteen minutes after the first application. It has been employed for the purpose of relieving the pain of operating on sensitive dentine or pulps, but good results are not always obtained. Dr. E. C. Kirk of Philadelphia has recently recommended its use in connection with devitalizing mixtures, as is noted under Arsenic. For the application of cocaine to dental practice, see p. 201 *et seq.*

Thea (TEA).—The dried leaves of the *Thea sinensis*, which contain an essential oil, tannic acid, and an alkaloid termed theine, $C_8H_{10}N_4O_2$.

Caffea (COFFEE).—The seeds of *Caffea Arabica;* they contain a volatile oil, an acid resembling tannic, and an alkaloid termed *caffeine*, isomeric with theine, but now believed to be not identical with it.

Many observations have been made upon the physiological effects of these two extensively-used stimulants, but much uncertainty still exists. Their action is dependent upon the volatile oil, as well as on the alkaloids they contain. *Caffeine* and *theine* produce cerebral excitement and wakefulness; they increase the heart's action, and then depress it. They have been used as cerebral stimulants in nervous headache. As a cardiac stimulant strong coffee is used to antagonize opium-poisoning. Caffeine and theine are usually regarded as identical, but several observers, among them Dr. T. J. Mays of Philadelphia, have shown that there is at least a slight difference.

Chocolate, Guarana, and Maté are three bodies similar in their effects and uses to coffee and tea, but they do not possess sufficient medical importance to warrant extended allusion.

(c) Agents which Depress the Motor Functions of the Spinal Cord and Sympathetic.

Conium (Hemlock).—Hemlock is the fruit of the *Conium maculatum*, or spotted hemlock, an umbelliferous plant which must not be confounded with the tree known as hemlock, as they are entirely different growths. Three alkaloids are contained in the plant under consideration—namely, conine, $C_8H_{15}N$, a liquid body powerful in its effects; methyl-conine and conhydrine. Of these alkaloids, *conine* is the most powerful. They are not official.

Preparations:
- *Abstractum conii:* dose, gr. ss.–ij.
- *Extractum conii alcoholicum:* dose, gr. ij–iv.
- *Extractum conii fluidum:* dose, ♏ij–v.
- *Tinctura conii:* dose, ♏x–f℥j.
- *Conine,* $C_8H_{15}N$ (unofficial): dose, ♏$\frac{1}{10}$–ij.

Physiological Effects.—Conium produces motor paralysis. A full dose of the drug causes at first nausea and vomiting, after which follows general weakness of the voluntary muscles. The heart is not directly affected. Death is produced by asphyxia following paralysis of the respiratory muscles. Poisoning by conium occasionally occurs among children from eating the herb. Nux vomica and picrotoxin are the physiological antidotes. Active muscular exercise also counteracts the effects of the drug.

Therapeutics.—Conium is chiefly employed to diminish muscular agitation, as in chorea, or to lessen the excessive muscular movements of acute mania or delirium tremens. In dislocations where the muscular system resists efforts at reduction it has been found efficacious in producing relaxation. Dr. Harley recommends its use in cases where artificial teeth or other foreign bodies have lodged in the œsophagus: the muscular walls of the tube being relaxed, efforts at removal are not resisted, and as the patient retains consciousness and sensation, he is able to a certain extent to co-operate with the surgeon and direct him to the point of impaction. Locally applied, conium possesses anodyne effects; it is useful in neuralgias, and seems to be specially effective in diminishing the pain of cancerous growths, for which, indeed, at one time it was regarded as a specific. It has been found efficacious in relieving pain in inflammation of the dental pulp. The poisonous nature of the drug and the disagreeable mouse-like odor of its chief alkaloid render its use in the mouth objectionable; and as there are other agents more effective, it is not often employed in dental practice.

Curare (Woorara) is a blackish-brown substance obtained by South American Indians, by processes known to themselves, from several plants of the Strychnos family, extracts of which are combined to form the drug. It is used by them as an arrow-poison. Its absorption from the stomach is very slow, but when injected beneath the skin it rapidly produces a general muscular paralysis, including the muscles of respiration. Primarily the heart and brain are not affected, and the cardiac movements continue long after the beginning of respiratory paralysis. The dose of the drug is $\frac{1}{20}$ to $\frac{1}{10}$ of a grain. As a motor depressant it

is chiefly employed to produce entire cessation of voluntary movement in the lower animals during physiological experimentation.

Gelsemium, the rhizome of the yellow jasmine, *Gelsemium sempervirens*, is analogous to conium in the muscular relaxation it produces. It is powerfully diaphoretic, slows the heart, and reduces the temperature. The preparations are *extractum gelsemii fluidum*, dose ♏ij–xv, and *tinctura gelsemii*, dose ♏v–xx. *Gelsemine*, $C_{11}H_{19}NO_2$ (unofficial), is the alkaloid: dose, gr. $\frac{1}{60}$–$\frac{1}{20}$.

The therapeutic action of gelsemium is similar to that of conium. It has much reputation as a remedy in the treatment of remittent fevers and of spinal meningitis.

Arnica.—*Arnicæ flores* and *Arnica radix* are respectively the flowers and the dried rhizome of the *Arnica montana*. These contain several active principles, of which the most important is *trimethylamine*, $(CH_3)_3N$.

PREPARATIONS:
Tinctura arnicæ florum: dose, ♏v–xxx.
Tinctura arnicæ radicis: dose, ♏v–xxx.

PHYSIOLOGICAL ACTION.—Arnica is diuretic, and antipyretic, at first stimulant, and then depressant, to the circulatory and respiratory systems, and also to the nervous centres. Given in excessive doses, it causes vomiting and purging, and in toxic doses death from collapse. Locally applied, it is stimulant. Unpleasant constitutional symptoms have followed its too profuse application to the skin.

THERAPEUTICS.—Arnica is employed internally chiefly as a stimulant in typhus and typhoid conditions. In rheumatism and rheumatic gout it has been found effective in reducing the temperature and slowing the pulse. Locally, it is largely employed as a lotion in sprains, bruises, and in external inflammations. In dental practice it has some reputation as an application in inflammation of the peridental membrane and to inflammations of the oral mucous membrane. In the latter condition a mixture composed of equal parts of tincture of arnica and glycerin, diluted with water as used, sometimes makes an effective mouth-wash.

Pilocarpus (JABORANDI) is the leaves of the *Pilocarpus pennatifolius*, a Brazilian plant belonging to the family of the Rutaceæ. It contains two alkaloids, *pilocarpine* and *jaborine*, which have the same chemical composition ($C_{11}H_{16}N_2O_2$), but are physiologically antagonistic.

Atropine antagonizes the action of pilocarpine.

PREPARATIONS:
Extractum pilocarpi fluidum: dose, ♏v–f℥j.
Pilocarpinæ hydrochloras: dose, gr. $\frac{1}{8}$–$\frac{1}{2}$.

PHYSIOLOGICAL ACTION.—Jaborandi produces paralysis of the vasomotor system. The action of the heart is increased, but arterial tension lowered. The temperature is reduced from one degree to four degrees. It is the most powerful of the diaphoretics, the increase of perspiration being very great. The secretion of the salivary glands is also much augmented, as much as twenty-seven fluid ounces being reported as the product of a full dose.

THERAPEUTICS.—Jaborandi is much employed in the treatment of dropsies, both cardiac and renal. It is contraindicated when the heart is weak, but by promoting the action of the skin and mucous surfaces the kidneys are relieved. Ptyalism is lessened by pilocarpine hydrochlorate given in doses of one-third of a grain three or four times daily. Dr. Ritter recommends the fluid extract in doses ♏x–f℥j at bedtime as a good remedy for common colds.

Physostigma (CALABAR BEAN) is the seed of the *Physostigma venenosum.* It contains an alkaloid, *eserine* or *physostigmine*, $C_{15}H_{21}N_3O_2$, which is the active principle.

PREPARATIONS:

Extractum physostigmatis: dose, gr. $\frac{1}{6}$–j.
Tinctura physostigmatis: dose, ♏v–xx.
Physostigminæ salicylas: dose, gr. $\frac{1}{100}$–$\frac{1}{60}$.

ANTAGONISTS.—Atropine and chloral.

PHYSIOLOGICAL ACTION AND THERAPEUTICS.—Physostigmine stimulates muscular fibre, voluntary and involuntary, and paralyzes the spinal cord, the medulla, and the sensory nerves. The motor nerves are very slowly affected, and the brain is but little influenced. It stimulates the salivary, the lachrymal, and the sweat-glands and mucous glands generally. Physostigma causes marked contraction of the pupil, increases the power of accommodation, and diminishes intraocular tension.

Physostigma is administered in constipation and in tetanus. Its use is principally by oculists for the purpose of contracting the pupil and lessening intraocular tension, to meet which indications a solution of physostigmine or of one its salts is employed locally

Acidum Hydrocyanicum Dilutum.—Hydrocyanic acid or prussic acid is hydrogen cyanide, HCN. The official preparation contains 2 per cent. of the pure substance. It is a colorless liquid, with an odor recalling that of crushed peach-kernels or bitter almonds. The leaves, bark, and seeds of many plants belonging to the rose family contain organic principles which when mingled with water decompose and produce hydrogen cyanide, so that the infusions of these substances contain this body. The dose of the official dilute acid is gtt. j–ij.

Two derivatives from hydrogen cyanide are official: *Potassii cyanidum*, potassium cyanide, KCN, a white crystalline salt having properties similar to the hydrogen compound: dose, gr. $\frac{1}{20}$–$\frac{1}{2}$.

Potassii ferrocyanidum, potassium ferrocyanide, a double salt forming lemon-yellow masses soluble in water, not distinctly poisonous: dose, gtt. j–ij.

PHYSIOLOGICAL ACTION AND THERAPEUTICS.—Hydrogen cyanide is one of the most rapidly fatal poisons known, death having occurred in a few moments from half a grain of the pure acid. It produces sudden and complete asphyxia, paralyzes the heart and lungs, and is supposed to act chemically on the blood-corpuscles. It can penetrate the skin. Atropine hypodermically, which antagonizes it, and ammonia by inhalation, are remedies to use if time permits. It has been used as an antispasmodic and sedative in spasmodic cough and painful

affections of the stomach, also locally, much diluted—fʒss of the official preparation to f℥j of water—to the *unbroken* skin in distressing itching.

The commercial preparations are very variable in quality, and care must be taken in the use of the acid. It is not suitable for any local applications in dentistry.

Tobacco.—Tobacco is the dried leaves of the *Nicotiana tabacum.* It contains an active and poisonous liquid alkaloid, *nicotine.* Tobacco-smoke contains little nicotine, but holds other products which have a powerful action. There are no official forms. It is now not much used in medical practice, on account of the dangers attending its employment.

Physiological Effects.—Tobacco is well known as a depressant, nauseant, and motor-paralyzer, the paralytic condition being preceded by a condition of tetanic spasm. It increases the salivary and intestinal secretions. Nicotine is a powerful poison, for which strychnine is physiologically antagonistic.

Therapeutics.—The antispasmodic and relaxing action of tobacco has suggested its use in constipation, tetanus, asthma, and other affections attended by spasm; but it is a dangerous remedy. Nicotine, hypodermically, in $\frac{1}{24}$-grain doses, is recommended in strychnine-poisoning, and in larger doses, even up to one minim, in tetanus.

The effects of the continued use of tobacco have been subject to much discussion, but there can be no doubt that it is capable in certain amount of doing much injury.

Tobacco has no use in dental disorders, except as an application to relieve the pain from an exposed pulp, for which tobacco-users sometimes find it quite efficacious. Preservative properties as regards the teeth have been claimed for the practice of chewing the weed, but such claims are of very doubtful validity, and even if carious action is in any degree retarded, such benefit is far more than counterbalanced by excessive attrition and by impairment of the general health. Caries in the teeth of tobacco-chewers is very apt to progress to full pulp-exposure without pain to the patient, the dentinal fibres and pulp-tissue being kept in a partially narcotized condition by the constant presence of the drug in the mouth. Such exposures of the pulp are very difficult to treat conservatively.

Lobelia (Lobelia).—The leaves and tops of the *Lobelia inflata*, an herb known as Indian tobacco. It contains a liquid alkaloid, *lobeline.* It resembles tobacco in its action, and is, like it, a very powerful poison. It is much used in irregular practice. Strychnine is antagonistic.

Preparations:

Extractum lobeliæ fluidum: dose, ♏j–x.
Tinctura lobeliæ: dose, ♏v–xxx.
Acetum lobeliæ: dose, ♏v–ʒj.

Physiological Action and Therapeutics.—Lobelia is expectorant, emetic, antispasmodic and motor depressant, and stimulates the secretions generally. It ultimately diminishes blood-pressure and paralyzes the respiratory apparatus. Lobelia is employed in spas-

modic asthma and dry tickling cough. The tincture is used in ten-minim doses in constipation. Lobelia has no special dental uses.

Aconitum (ACONITE).—Aconitum is the tuberous root of the *Aconitum napellus*, a plant which chiefly abounds in the mountainous regions of Asia and Europe. It contains about .03 per cent. of a very active alkaloid, *aconitine*, besides several other organic principles.

PREPARATIONS:

Abstractum aconiti: dose, gr. $\frac{1}{4}$–j.

Extractum aconiti, which, it must be remembered, is at least *four times as strong as the older form of extract made from the leaves:* dose, gr. $\frac{1}{6}$–$\frac{1}{3}$.

Extractum aconiti fluidum, a drop representing one grain of the drug: dose, ♏$\frac{1}{2}$–♏ij.

Tinctura aconiti. This is very *much stronger than the former tincture of the leaf*, which is no longer official. It contains a small quantity of tartaric acid: dose, ♏$\frac{1}{2}$–♏iv.

Since the strength of the tincture is subject to some variation, and as it is a powerful preparation, it is best to begin with the minimum dose.

The active principle, *aconitine*, is not official, but is frequently used. The commercial article is variable in character. The dose is very small, $\frac{1}{200}$–$\frac{1}{60}$ of a grain.

PHYSIOLOGICAL ACTION.—While there are several organic principles in aconite having physiological activity, aconitine is practically the one on which the action of the drug depends. It is a powerful depressant of the heart and respiration. It is antipyretic, and diaphoretic and diuretic. Aconite paralyzes first the sensory, then the motor nerves, but it does not affect the cerebrum. Applied locally in small amount, especially to the mucous membrane, a sensation of tingling and numbness is felt. In larger quantity it produces constriction of the throat, diminished pulse and respiration, nausea, and vomiting. In poisonous doses muscular weakness, dilated pupils with defective vision, labored respiration, weak pulse, and cold skin are among the symptoms observed. Consciousness is preserved for some time. The effects of the drug last for some hours. Atropine, morphine, and ammonia antagonize aconite. Cases of poisoning must be treated with alcoholic stimulants, warmth, and artificial respiration.

THERAPEUTICS.—Aconite is now generally recognized as one of the most valuable of known agents for the control of inflammatory conditions. As it lowers arterial pressure, lessens the force and frequency of the heart's pulsations, reduces the temperature, and stimulates the intestinal, cutaneous, and urinary secretions, it directly antagonizes inflammatory and febrile states, and for this use has almost entirely supplanted general bloodletting. It is especially efficacious in inflammations of the respiratory tract, such as acute bronchitis, pleuritis, and pneumonia, as also in catarrhal fever and in tonsillitis. In the eruptive fevers also, such as scarlet fever, it is often of signal service; and while it does not antagonize the specific contagion, it controls the violence of the inflammatory complications which are often so destructive in character. Over-action of the heart, without valvular lesions or hypertrophy, is often readily controlled by aconite. Neuralgias also, especially of the sthenic type, are usually much benefited.

In inflammation of the peridental membrane aconite is not less efficacious than in similar conditions of other organs. To be fully effective,

the remedy must be pushed until its full physiological effects are exhibited: pain will then be obtunded, arterial tension lessened, and the force and frequency of the cardiac impulses upon the inflamed tissue diminished, the inflammatory processes being thus held in check until resolution ensues.

It need hardly be remarked that with so powerful an agent the utmost care and watchfulness must be observed in its administration. The amount required to produce effective results will vary with the violence of the disease, the constitution of the patient, and the strength of the preparation,—all of which are variable conditions to be learned only by careful clinical observation of each case. On p. 929, Vol. I., of this work some of the practical details in the administration of aconite in dental inflammations are given, and to these the reader is referred.

As a local application in inflammation of the root-membrane aconite is often employed, but generally in combination with other agents. Equal parts of tincture of aconite and tincture of iodine is a favorite formula, the mixture to be applied with a camel's-hair pencil to the gum over the affected root. A combination of tincture of aconite and chloroform, equal parts, is also much employed. This may be applied in the same manner as the above, or, if more decided counter-irritant effects are desired, the mixture may be carried on a pledget of cotton to the part and be held there until the required result is obtained.

To secure local analgesic effects in tooth-extraction the following formula may be employed:

Take of Tincture of aconite, f℥j;
Menthol, gr. x;
Chloroform, f℥j. M.

S. Apply freely to the gum-tissue around the tooth to be extracted, continuing the application for several minutes.[1]

Veratrum Viride.—Veratrum viride is the underground stem of the *Veratrum viride*, swamp hellebore.

Veratrum Album, the rhizome of the *Veratrum album*, is closely allied to *Veratrum viride*, and much resembles it in appearance.

Veratrum Sabadilla (cevadella) is the dried fruit of *Asagræa officinalis*.

The following are the leading alkaloids severally furnished by these plants:

Veratrum viride, jervine, pseudo-jervine, rubijervine.
Veratrum album, jervine, pseudo-jervine, rubijervine, veratralbine.
Veratrum sabadilla, veratrina.

PREPARATIONS:
Extractum veratri viridis fluidum: dose, ♏j–iv.
Tinctura veratri viridis: dose, ♏ij–x.
Veratrum album (in powder): dose, gr. j–ij (no official preparations).
Veratrum sabadilla, not official.
Veratrina: dose, gr. $\frac{1}{50}$–$\frac{1}{10}$.

PHYSIOLOGICAL ACTION.—In its action on the heart veratrum viride is powerfully depressant, rendering the pulse slow, soft, and compres-

[1] For further allusion to the use of aconite in dental practice see p. 199, this volume.

sible. Under full doses of the drug the pulse-rate can be reduced to as low as forty, or even thirty-five, beats to the minute. It is less depressing to the respiration than aconite, and also differs from that agent in the fact that it is less diaphoretic and diuretic in its action. Veratrum viride generally, but not invariably, produces more or less violent vomiting, and frequently purging. The intense nausea which so generally follows its administration renders it in many cases a much more objectionable remedy for internal use than is aconite, although the emeto-cathartic effect is a safeguard against over-dosage, and very few cases of fatality have followed its use. The depressant action of the drug is to a certain extent due to the alkaloid jervine.

Therapeutics.—Veratrum viride is, like aconite, serviceable in depressing the action of an irritable heart when no valvular lesions exist. It is also used to meet many of the same indications as aconite in fevers and inflammations. By many practitioners it is regarded as almost a specific in pneumonia, and it unquestionably possesses great efficacy in that disorder. In dental practice it is but little employed, although it is, for internal administration, doubtless, a safer remedy than aconite, and might be substituted for that drug should occasion require.

Effects and Uses of Veratrum Album.—This agent is a violent gastro-intestinal irritant, the nausea produced being intense and persistent, while the catharsis is attended with bloody stools. In large doses it rapidly produces intense depression of the circulation, respiration, and all the vital forces. The drug was at one time administered in dropsy, and a decoction was externally applied to destroy parasites, but it is now very rarely employed.

Effects and Uses of Veratrina.—This alkaloid, which is the only official preparation of *Veratrum sabadilla*, is a pale, gray, amorphous powder, without smell, but excessively irritating to the nostrils. To the taste it is acrid and bitter. In water it is almost insoluble, but is soluble in alcohol, ether, chloroform, and glycerin. In its action it is, like other members of this group, a gastro-intestinal irritant and a powerful depressant of the circulation and respiration. It has no marked action on the brain, but produces paralysis of both motor and sensory nerves. It is chiefly employed in the form of an ointment as a local application for superficial neuralgia and localized headache. *Unguentum veratrinæ* is official. As the drug may be absorbed and give rise to dangerous symptoms, it must be used with care. In dental practice it has been chiefly employed as an obtundent of sensitive dentine, and enters into the following formula of Dr. Bogue, employed by him for that purpose:

Take of	Veratrina,	gr. iv;
	Tannic acid,	gr. j;
	Alcohol,	gtt. xx;
	Glycerin,	f℥j;
	Carbolic acid,	ℨij. M.

S. Thoroughly dry the tooth and apply to the sensitive surface.

Amyl Nitris (Amyl Nitrite, $C_5H_{11}NO_2$).—This belongs to the class

of compound ethers. It is a yellowish, highly volatile liquid, insoluble in water. The dose by the stomach is ♏︎$\frac{1}{4}$–j, and by inhalation ♏︎ij–iv. It is frequently put up in small glass capsules containing a few drops, which are crushed when needed. In addition to this body, several other nitrites have been brought forward: $NaNO_2$, sodium nitrite; KNO_2, potassium nitrite; and $C_3H_5(NO_3)_3$, propenyl nitrite, nitro-glycerin. The latter is used in extremely dilute alcoholic solution, the dose of which is about one drop.

Physiological Action and Therapeutics.—The nitrites act powerfully in paralyzing the action of the smaller arteries, causing their dilatation, and also relaxing the inhibition of the heart. They affect respiration, and also the composition of the blood, and cause headache, which is often prolonged. Ergot, belladonna, and other spinal stimulants are antagonistics.

Amyl nitrite is employed as a remedy for spasmodic affections of the respiratory tract, such as whooping cough (spasmodic asthma), and has been used in threatened chloroform narcosis, in which it is thought to antagonize cerebral anæmia by producing capillary dilatation, and thus favoring the inflow of blood to the brain. Its inhalation is resorted to to prevent epileptic seizures, and is also useful in angina pectoris and in tetanus. Nitro-glycerin has been used with success in neuralgias of the fifth pair of nerves, and in sick headache attended with brain anæmia.

(*d*) Agents which Diminish the Functional Activity of the Cerebrum after a Preliminary Stage of Excitement.

Alcohol.—The term "alcohol" is ordinarily applied to a liquid containing about 94 per cent. by volume of ethyl hydroxide, C_2H_5HO, known as absolute alcohol, and 6 per cent. of water. The term "alcohol" is now extended by chemists to a group of bodies, hydroxides of hydrocarbon radicles. Ethyl alcohol is a colorless, faintly odorous, inflammable liquid, lighter than water. It is a product of the fermentation of sugar.

Preparations:

Alcohol dilutum contains equal parts of the official alcohol and distilled water.

Spiritus frumenti, whiskey, obtained from the distillation of fermented grains, and to be at least two years old. It contains 46 per cent. of alcohol.

Spiritus vini gallici, brandy, obtained by the distillation of grape wine, and to be at least four years old. About 44 per cent. of alcohol.

Spiritus odoratus, a mixture of alcohol with various essential oils.

Vinum album, white wine, *Vinum rubrum*, red wine, are standard official liquors.

Vinum album fortius is made by adding alcohol to white wine; *Vinum aromaticum*, by adding to white wine various aromatics.

Physiological Action.—Alcohol is a cerebral excitant and a narcotic poison. It is antiseptic and anæsthetic, and produces coagulation of albumen by the abstraction of water. Amounts less than f℥iss in twenty-four hours may be used up in the system, but the continued use of even small amounts produces sclerosis and steatosis of the connective tissue of the various organs. The general question of the effects and dietetic value of fermented liquors cannot be discussed here.

In small doses alcohol relaxes the vessels, stimulates digestion, lessens

the elimination of carbon dioxide and urea, and slightly raises the temperature. In larger doses much disturbance of the principal functions occurs.

THERAPEUTICS.—Alcohol has been regarded as a specific for snake-venom, and is largely used as a stimulant in low fevers and during convalescence from acute diseases. Brandy is much employed in the treatment of infantile diarrhœa. The therapeutic effects can in most if not all cases be obtained from artificial mixtures of pure alcohol, which, if scientifically made, are equal to the natural ones.

Alcohol is employed in dentistry as a styptic and antiseptic and for obtunding sensitive dentine. For the latter use the absolute alcohol should be used, as its obtundent power is chiefly dependent upon its affinity for water, which it abstracts from the protoplasmic contents of the tubuli. This property makes it useful also in removing moisture from cavities previous to filling them. The cavity should first be thoroughly dried and the alcohol then applied. The styptic action may be utilized to stop hemorrhage after extraction: it coagulates the blood and contracts the mouths of the bleeding vessels. Its antiseptic qualities make it useful as a mouth-wash when the secretions are fetid and the mucous surfaces soft and spongy. It may also be very usefully employed to cleanse the pulp-canals of pulpless teeth preparatory to the application of more active antiseptic agents. Owing to its great value as a solvent, it enters into a large number of the formulæ employed in dental practice.

Paraldehyde, $C_6H_{12}O_3$.—This is a modification of aldehyde, polymeric in character, three molecules of aldehyde, C_2H_4O, being combined, as seen in the above formula. It is a colorless liquid, soluble in eight parts of water, and becomes solid below 51° F. Paraldehyde has decided hypnotic powers, being analogous to chloral in this influence, although the sleep produced is neither so deep nor so prolonged as with the latter drug; but as it does not weaken the heart, it is the safer of the two agents. In poisonous doses paraldehyde produces respiratory paralysis. It is chiefly employed as a remedy in insomnia. The dose is ♏xv–f℥j, repeated if necessary. It is not official.

Æther (ETHER).—Ether, ethyl oxide $(C_2H_5)_2O$, is a product of the action of sulphuric acid on alcohol. The term "ether" is also used in wide sense for a class of compounds containing hydrocarbon radicles. The term "sulphuric ether," which was formerly the official designation of the substance (æther sulphuricus), and which is still sometimes applied to it, is a misnomer, as it contains no sulphur compounds, although it is prepared by the aid of sulphuric acid. If used at all, the term "sulphuric ether" would be more properly applicable to ethyl sulphate than to ethyl oxide.

Æther, Ether.—This contains 74 per cent. of pure ether and about 26 per cent. of alcohol, with a little water.

Æther fortior, stronger ether, contains about 6 per cent. of alcohol. It is a colorless, very mobile, inflammable, liquid, lighter than water, and very volatile. It is the form employed for anæsthetic use. Dose, when administered by the stomach, ♏x–f℥j.

Physiological Action.—Ether is anæsthetic, antispasmodic, anodyne, in small doses stimulant, in large doses a narcotic poison. When given internally it increases the secretions of the salivary glands, pancreas, and stomach. Its volatility makes it a refrigerant and local anæsthetic when applied externally, but if kept from evaporating it acts as a rubefacient. When inhaled the anæsthetic effect is attended by partial suspension of the cerebral functions; the muscles are relaxed, and if carried too far the respiration is affected.

(For a full discussion of ether and its anæsthetic uses see p. 57, *et seq.*)

Preparations:

Several preparations of ether are employed in medical practice.

Oleum æthereum, ethereal oil, consists of equal volumes of heavy oil of wine and stronger ether. It is used in the preparation of

Spiritus ætheris compositus, Hoffman's anodyne, which contains 3 per cent. of ethereal oil in ether and alcohol. It is used as an anodyne in gastralgia, colic, and hysterical conditions. In association with paregoric it is used for summer diarrhœa: dose, ♏v–f℥j.

Spiritus ætheris, spirit of ether, is a 30 per cent. solution of stronger ether in alcohol: dose, ♏x–f℥j.

Spiritus ætheris nitrosi, spirit of nitrous ether, sweet spirit of nitre. This long-known remedy is an alcoholic solution of ethyl nitrite ($C_2H_5NO_2$), of which it should contain 5 per cent. It is used as a diaphoretic, diuretic, and carminative; also as an antipyretic and anodyne: dose, f℥ss–f℥ss.

Ethyl iodide, hydriodic ether, C_2H_5I, is an antispasmodic and anæsthetic, but its chief use is a means of producing quickly the therapeutic influence of iodine. It is used by inhalation: dose, ♏xv.

Ethyl bromide, hydrobromic ether, C_2H_5Br, was introduced as a substitute for ether as an anæsthetic. It is non-inflammable, and produces but little irritation of the air-passages: dose, internally, ♏x–f℥j.

Chloroformum (Chloroform, $CHCl_3$).—Chloroform is methane, CH_4, in which H_3 is replaced by Cl_3. It is obtained by the action of chlorine on alcohol. It must be carefully purified for internal use.

Chloroformum venale, commercial chloroform, is employed only for pharmaceutical purposes or external use. It is too impure for inhalation.

Chloroformum purificatum, purified chloroform. This is a very carefully purified article, containing only a small amount of alcohol, and is a colorless, volatile, fragrant liquid, much heavier than water, and not easily inflammable: dose, internally, is ♏ij to xx, in syrup.

Preparations:

Mistura chloroformi contains 8 per cent. of purified chloroform, with camphor and yolk of egg and water: dose, f℥j–f℥j.

Spiritus chloroformi is a 10 per cent. alcoholic solution: dose, ♏x–f℥j, much diluted.

Linimentum chloroformi, a mixture of soap liniment and commercial chloroform.

Physiological Action.—Although the vapor of chloroform is not as unpleasant as that of ether, it is more irritating locally. It depresses the heart more and respiration less. In inhalation a large amount of air is required for safety. Chloroform should never be given in the upright posture.

Therapeutics.—Chloroform is much used in liniments as a rubefacient and anodyne. Internally, by the stomach, it has been of service in cholera and cholera morbus. In painful affections of the nerves it has been employed successfully as a hypodermic injection, ♏v–xv, over the seat of pain, although considerable, and even dangerous, local

disturbance may ensue. A mixture of equal parts of chloroform and creasote has been recommended for odontalgia. Water impregnated by agitation with chloroform is an efficient hæmostatic, especially for operations about the mouth. (For the anæsthetic uses of chloroform see p. 104, *et seq.*)

ANÆSTHETICS RESEMBLING CHLOROFORM.—The list of "chlorine substitution" compounds already known is very large, and such of them as are gases or volatile liquids probably have anæsthetic powers. They are all open to the physiological dangers which belong to chlorine compounds. Several have, however, been strongly indorsed, among which the following may be named:

Ethylene dichloride, ethene chloride, Dutch liquid, $C_2H_4Cl_2$. This is said to be safer than chloroform, and to affect the respiration before depressing the heart, so that its effects can be more easily watched.

Methene dichloride, dichloro-methane, CH_2Cl_2, belongs to the same substitution series as chloroform, and was at first supposed to be safer than chloroform, but it is not so.

Carbon tetrachloride, CCl_4, is the last step in the substitution of chlorine for hydrogen in methane, and is the most dangerous of the series.

The chlorides of several hydrocarbons (alcohol radicles) have also been used; *e. g.* ethyl chloride, C_2H_5Cl; methyl chloride, CH_3Cl; amyl chloride, $C_5H_{11}Cl$.

Chloral (CHLORAL HYDRATE).—This substance is prepared by passing chlorine gas through absolute alcohol. The anhydrous product, pure chloral, has the formula C_2HCl_3O, and is a colorless liquid which combines with distilled water to form a hydrate, $C_2HCl_3OH_2O$, which is the official body, a white crystalline substance soluble in water and possessing a somewhat pungent odor. There is also known a compound of chloral with alcohol which is insoluble in water. The dose of chloral hydrate, about twenty grains, may be repeated once or twice. Too large a dose will produce nausea and gastric inflammation.

PHYSIOLOGICAL EFFECTS.—Chloral in doses of twenty grains has a hypnotic action, inducing a quiet, natural sleep, with comparatively slight after-effects. It does not directly relieve pain, as opium does, and has no special action on the secretory organs. In special cases it causes excitement instead of sleep. The effect is somewhat irregular, for large doses have been taken without fatal result, and several cases are now recorded in which twenty grains have produced death. In fatal doses it produces profound unconsciousness, diminished respiration, pulse, and temperature, death occurring by failure of the heart. In the treatment of chloral-poisoning advantage is taken of the antagonistic effects of strychnine, which is to be administered hypodermically.

THERAPEUTICS.—Chloral is used as an hypnotic and antispasmodic in insomnia, hysteria, acute mania, and delirium tremens. It has been employed in tetanus, whooping cough, chorea, and occasionally in gastralgia, renal and intestinal colic, and neuralgia. It is one of the physiological antidotes to strychnine-poisoning. Chloral is sometimes of service in sea-sickness. Bartholow highly recommends its hypo-

dermic injection in the collapse of cholera. Chloral must be used with caution in persons with fatty heart, degenerated blood-vessels, or pulmonary disease. Chloral enters into several formulæ for the relief of odontalgia. A recently-suggested combination is given on p. 690.

Local application of dilute solution of chloral in water has been recommended in the treatment of inflammations of the buccal mucous membrane.

An ointment (chloral, ʒss; lard, ℥j) is advised as an application to foul and fetid ulcers. As a local anæsthetic, chloral has been superceded by cocaine.

The antiseptic powers of chloral render it a serviceable agent in the treatment of putrescent pulp-canals, and it is also of service as a stimulant and antiseptic injection in chronic alveolar abscess. For these uses à strong solution (chloral, ʒj; aqua, fʒij) should be employed.

Butyl chloral (croton chloral) is analogous to chloral, but has the formula $C_4H_5Cl_3O$. It forms a hydrate, and agrees in its physiological action with chloral, but is weaker.

Opium.—Opium is obtained from unripe capsules of the *Papaver somniferum.* The important constituents are a series of organic bases, among which morphine is the most valuable. Good opium will contain over 10 per cent. of morphine, and the therapeutic effect of the drug is due principally to that alkaloid.

PREPARATIONS:

Of the many preparations only those in regular use need be specified:

Pulvis opii: this should contain from 12 to 16 per cent. of morphine: dose, gr. i–ij.

Tinctura opii, laudanum. The formula of the U. S. P. 1880 calls for 10 per cent. of powdered opium, containing from 12 to 16 per cent. of morphine, but some manufacturing pharmacists still adhere to the older (1870) process, or employ lump opium, which does not contain the required percentage of morphine. This variability in the strength of the commercial laudanum should be kept in mind. The dose of the official preparation is about ♏v to xx, according to the effect required.

Tinctura opii camphorata, paregoric: dose, fʒj–ij.

Pulvis ipecacuanhæ et opii, Dover's powder: dose, gr. x.

Opium denarcotisatum: dose, gr. ss–ij.

Extractum opii: dose, gr. ¼–j.

Tinctura opii deodorata: dose, ♏v–xx.

Vinum opii: dose, ♏v–xx.

Acetum opii: dose, ♏v–xx.

Alkaloids of Opium.—Morphine is the most abundant and the essential alkaloid. Narcotine, codeine, narceine, papaverine are generally present in small proportions.

Morphina, morphine, $C_{17}H_{19}NO_3H_2O$. This exists in opium combined with meconic acid. It forms colorless bitter crystals slightly soluble in cold water. It combines easily with acids, forming crystallizable salts which are mostly more easily soluble in water than the free alkaloid. Among these are *morphinæ sulphas, morphinæ acetas, morphinæ hydrochloras,* the sulphate being the more stable and the acetate the more soluble of the three. Morphine and its salts are given in doses varying from one-sixth to one-half grain.

PHYSIOLOGICAL EFFECTS.—The physiological activity of opium and its alkaloids is essentially dependent on morphine, but the alkaloid is said to be less constipating, less diaphoretic, and less nauseating than

opium, and to produce more itching of the skin. One-sixth of a grain is usually considered the equivalent of a grain of opium, and in this proportion the active principle is more powerfully hypnotic than the drug.

In average medicinal dose, one grain, opium quickens the pulse and flushes the skin, and a general stimulant effect is produced in which, according to Christison, the will-power is increased. This period of stimulation is quickly succeeded by a sleep which is not comatose and which is due to anæmia of the brain, brought on through vascular depression and a diminished activity of the cerebral cells, in consequence of which their demand for a blood-supply is lessened. These are believed to be the essential factors in the hypnotic effect of the drug. In full medicinal dose the condition of drowsiness soon comes on, and becomes more or less profound; the pulse is slow and relaxed, the skin moist, and an intense general itching is often noticed. If the dose be still larger, the toxic condition occurs, with profound unconsciousness, generally stertorous breathing, contracted pupils, moist skin, and relaxed muscles. Death occurs from paralysis of the respiratory centre, sudden failure of the heart being of rare occurrence Half a grain of morphine is the smallest dose known to have been fatal to an adult. Persons not accustomed to the use of opium usually experience some unpleasant after-effects, such as headache, nausea, vertigo, and constipation, from even moderate doses. With the exception of the milk and sweat, which are increased, the secretions generally are diminished by the preparations of opium in any dose.

In its action on the nervous system opium appears to influence first the cerebrum, primarily stimulating and then depressing its perceptive and sensory functions; the respiratory and cardiac ganglia are also similarly influenced, but the latter to a less degree than the former: the spinal cord, at first stimulated, also soon shares in the general depression, and motor paralysis, more or less complete, soon follows.

Children and old people, especially the former, are very susceptible to the action of opium, and it must be used with caution with this class of patients. Some persons are by idiosyncrasy very intolerant of it. Habitual use, on the other hand, and great pain cause remarkable tolerance.

Atropine by its stimulant effect on the heart and respiration antagonizes the action of opium, but it must be used with care, gr. $\frac{1}{120}$, hypodermically, two or three times, being usually the limit, as in large doses atropine produces cardiac and respiratory paralysis. Caffeine is also antagonistic, and strong coffee has long been used in opium-poisoning. Electrical stimulation is also of service. Alkaline solutions, carbonates, and salts of the common metals are incompatible with opium preparations.

Therapeutics.—The most important functions of opium are to relieve pain and to produce sleep. It is also used to control nervous and vascular irritability, to stimulate the perspiratory functions, and to check excessive secretion from the intestines, kidneys, salivary glands, etc. In its power to relieve pain it stands unrivalled, and it is employed for that purpose in nearly all painful affections except brain inflammations, in which it is by many considered as contraindicated,

and in those gastro-enteric affections in which the function of the kidney or liver is suspended. Opium has sedative power not only when externally administered, but when locally applied.

Externally, solutions of morphine are used to lessen pain in conjunctivitis, iritis, and other inflammatory ocular affections, and also in ear-ache. Local inflammatory swellings are often relieved by poultices containing laudanum or by laudanum in hot water (fʒj–f℥iij), applied on cloths, which should be kept constantly wet with the lotion. In painful affections of the rectum, such as hemorrhoids, fissures, and ulcers, opium or morphine made up with cacao-butter (*oleum theobromæ*) into the form of suppositories, are often efficacious. They also frequently enter into the composition of the various ointments applied in such cases.

Morphine is more frequently employed in the treatment of neuralgia than is any other remedy. Either the endermic or hypodermic method may be employed. Since the introduction of the latter mode of medication the endermic process (an application to the skin deprived of its epidermis by a blister) has been relatively but little employed. It is, however, an excellent method for securing local as well as constitutional effects from morphine, and is especially serviceable in sciatica. When the hypodermic process is resorted to in such cases care must be taken not to thrust the nozzle of the syringe into the nerve-trunk; all that is requisite is that it shall be introduced far enough to throw the solution around, but not into, the affected nerve. In painful gastric affections neuralgic in character, and also in those cases in which the pain is due to ulceration or to cancerous growths, the endermic or hypodermic application of morphine to the epigastrium is often alleviatory. In such cases morphine given by the stomach is better borne by that organ than are the preparations of opium, and its good effects are often enhanced by combination in powders with bismuth subnitrate or zinc oxide, which appear to exercise a locally sedative effect on the gastric mucous membrane. In cases of gastro-intestinal pain accompanied by intense inflammatory action, such as results from the swallowing of corrosive poisons, morphine is also indicated; and as the stomach is generally highly irritable, the hypodermic administration of the agent is generally resorted to, the epigastrium being frequently selected for the purpose. In acute peritonitis no remedy is so efficient as opium or its leading alkaloid. When the disease is in its incipiency it may often be promptly arrested by giving full doses of opium by the stomach (if not too irritable), pushing the drug until the pupils are contracted and the patient sufficiently narcotized to be comparatively free from pain. Not only is pain relieved and the inflammatory process controlled by the agent, but a cessation of intestinal movement highly favorable to recovery is secured. Of course to make the treatment effective the patient must be kept in a state of absolute rest and deprived of all food until the inflammation begins to abate. Hot fomentations are also of the utmost service. When, owing to gastric irritability, the opium preparations cannot be employed, morphine by the stomach or hypodermically may be substituted.

In acute diarrhœa and dysentery opium is often injudiciously administered. Very frequently in such cases what is needed is not a drug to

check intestinal secretion and peristalsis, but one to promote those processes. This is particularly true when the diarrhœic or dysenteric attack is due to the presence in the intestine of improper or undigested food, or where there is much tenesmus and a discharge of blood and mucus; in which cases the true indication is the administration of a mild saline cathartic to assist in freeing the intestinal tract from its irritative contents. The cause of the trouble being removed, recovery will generally follow without further medication, provided absolute corporeal, and, for the intestines, functional, rest is observed. After the operation of the saline draught small doses of opium, gr. $\frac{1}{2}$, three or four times daily, may be given to relieve pain and allay irritability. In cholera morbus, where there is such profuse outward osmosis of intestinal fluids, and also in chronic diarrhœa and dysentery and in the diarrhœa of phthisis, opium is often essential.

For influenza or "common cold" no remedy acts better than a full dose of opium (Dover's powder) taken at bed-time and under conditions to promote profuse diaphoresis, such as warm clothing, hot drinks, foot-baths, etc.

In the acute stages of bronchitis and in pneumonia and pleurisy opium is often a useful adjunct to aconite or veratrum viride, but used alone is not nearly so certain or effective as those preparations.

As an hypnotic, opium is used in acute mania, in delirium tremens, and in the insomnia of nervous prostration and of melancholia. In the latter disorders especially is there danger of establishing the morphine habit by the injudicious employment of the drug.

The spasm of renal, hepatic, and lead colic is relieved by the hypodermic use of morphia, one-eighth of a grain, cautiously repeated if necessary. Opium is of use in cases of weak and dilated heart, and favorably modifies the action of digitalis in these cases. The dose should be about five minims of the tincture. The employment of morphine hypodermically just prior to the use of chloroform has been found to be of advantage.

In dental practice opium may be very advantageously employed for the relief of pain and inflammation. Ten grains of Dover's powder, given at bedtime, will often prove of service in inflammations of the peridental membrane. (See Vol. I. p. 929.) Tincture of opium in hot water (tinct. opii, fʒij; aq. ferv., f℥x) is an excellent local application in the same class of cases. A convenient quantity should be held in the mouth around the affected tooth, the application being renewed from time to time. The heat of the mixture often gives relief, and, as a certain amount of opium is absorbed, the anodyne effect is not only local, but systemic. For wounded and inflamed gum-tissue after tooth-extraction a lead-and-opium wash is sometimes of decided service. A good formula is—

℞. Plumbi acetatis, gr. xv;
Tinct. opii, fʒij;
Aquæ, f℥iij. M.

Sig. Use as a mouth-wash.

Although mixtures of this kind are chemically incompatible, lead

meconate and morphine acetate being formed, good results generally follow their use in this class of cases. Lead-and-opium lotions, if long continued, cause a black deposit upon the teeth; this, however, is in the nature of a film which is readily removed. It is due to the presence of the lead.

Of the morphine salts the acetate is, owing to its greater solubility, the preferable preparation in dental practice. It is chiefly used as a local application for the relief of pain from exposed pulps and for diminishing the pain often caused by the action of arsenic when applied for the devitalization of the dental pulp; hence it is very generally an ingredient in the many "nerve-pastes" prepared from various formulæ for that purpose. The results, however, are not very satisfactory, and cocaine now largely displaces the local use of morphine for this purpose. As an anodyne application, without arsenic, in pulp-exposure, morphine is very generally effective. A good method of application is to rub up the morphine acetate with enough oil of cloves to form a thin paste, and apply on a pledget of cotton to the point of exposure. A mixture consisting of morphine acetate, grs. v, in oil of cajeput, f℥j, may also be applied in the same manner. The latter in combination is effective for the pain following tooth-extraction. It should be placed on cotton in the socket of the extracted tooth.

The specially injurious effects upon the teeth of the morphine habit, which has become so alarmingly rife since the widespread introduction into general practice of hypodermic medication, may here be noted. Cases are frequently seen in which the enamel and dentine of the teeth are thoroughly disentegrated, up to and even beneath the gum-line, this being in all probability due to the existence of erosive acids in the vitiated oral secretions. As the victim of the morphine habit is usually always more or less narcotized, even this extreme destruction of the tooth-substance is usually not attended by pain; but all the ordinary local measures for the arrest of the destructive process are quite futile, unless, indeed, in those rare instances in which the morphine habit, after having been once formed, is entirely abandoned.

Humulus (Hops).—Hops are the fruit-cones of the *Humulus lupulus*. They contain resin, tannin, a liquid alkaloid, volatile oil, *lupuline*, and a bitter principle, *lupulinic acid*. The alkaloid, called *lupuline*, must be carefully distinguished from *lupulin*, which is a fine powder secreted by the fruit-cones, containing the same active ingredients as these.

Preparations:

Tinctura humuli: dose, fʒj–f℥ij.

Lupulinum, lupulin, the glandular powder secreted by the hops, containing the characteristic volatile oil: dose, gr. v–xx.

Extractum lupulini fluidum: dose, fʒss–fʒij.

Oleoresina lupulini: dose, gr. ij–v.

Physiological Action.—Hops are tonic, astringent, slightly hypnotic. They stimulate the heart and promote cutaneous circulation. The tonic properties of hops are due to lupulinic acid, their primarily stimulant and then sedative effects to lupuline. Mineral acids and metallic salts are incompatible with hops.

Therapeutics.—Hops are used in early stages of delirium tremens

and also as a tonic in dyspepsia. As a mild hypnotic the hop-pillow is frequently employed, and the hop-poultice has long been a favorite domestic remedy for the relief of local inflammations. The fluid extract of lupulin is a convenient preparation for internal administration.

Potassii Bromidum.—Potassium bromide, KBr, occurs in white crystals freely soluble in water, slightly soluble in alcohol. It is generally used in solution, the dose being from five grains to sixty, preferably between meals. It is often given for a long time in large doses.

PHYSIOLOGICAL EFFECTS.—Potassium bromide possesses a sedative effect on the sympathetic system, and in very large doses lessens the force and frequency of the pulse and lowers the temperature. There is impairment of the functions of the spinal cord and brain, with diminution of reflex action. Under long-continued use of the drug depression of the sexual function occurs; also diminished mental power, impaired cutaneous sensibility, and an eruption acne-like in character. This train of symptoms is called *bromism*. The drug is chiefly eliminated by the kidneys, and is found in the urine very soon after administration.

THERAPEUTICS.—Potassium bromide is much in favor as a general hypnotic for cases of cerebral excitement unattended with severe pain, as in sleeplessness from overwork or worry or great mental strain. It may also be used in cases of so-called "nervousness," in which depression of spirits, irritability, and restlessness are symptoms. In convulsive nervous affections, whooping cough, chorea, and spasmodic asthma, and especially in epilepsy, it is very useful. Its depressing effect on the sexual organs has led to its use as an anaphrodisiac, and it is sometimes introduced into the food of male convicts for the purpose of diminishing the tendency to masturbation which exists among such classes. It has been successfully used as an antidote to strychnia-poisoning. When in its long-continued use symptoms of bromism arise, they may be stopped by temporarily withdrawing the remedy.

In dental practice potassium bromide may be given in full doses, grs. xx–xxx, twice or thrice repeated, to diminish irritability of the fauces when in cases of cleft palate an impression of the parts is about to be taken. In infantile convulsions dependent upon teething it is often of service. Good results follow its employment in facial neuralgia when congestive in type.

AMMONII BROMIDUM, ammonium bromide (NH_4Br);

SODII BROMIDUM, sodium bromide, NaBr;

LITHII BROMIDUM, lithium bromide, LBr;

CALCII BROMIDUM, calcium bromide, $CaBr_2$.

These have been proposed as substitutes for potassium bromide, but possess no marked advantages, except that sodium bromide is thought to be more hypnotic than others of the series. They are used to meet the same indications as potassium bromide, but are given in somewhat smaller doses, except sodium bromide, which is used in the full dose.

Lactucarium.—This is the concrete juice of the *Lactuca virosa*, a biennial European plant. The common garden lettuce or salad (*Lactuca sativa*) also furnishes it. It possesses to a slight degree the hypnotic

qualities of opium. *Syrupus lactucarii* (dose, fʒj–f℥j) was formerly substituted for opium in cough mixtures, but the drug is of little moment, and is now rarely used.

Remedies Promoting Constructive Metamorphosis.

Pepsinum (Pepsin).—This term is applied to various preparations of the nitrogenous material which forms the digestive ferment in the higher animals. It has the property of modifying, and especially of rendering soluble, the albuminoid principles of tissue, converting them into "peptones." Some of the commercial forms of pepsin contain admixture of milk-sugar; others contain dry peptones. The latter forms are more easily soluble, and are capable of being prepared in scale-form, and are generally preferred. The commercial pepsins are generally prepared from the stomach of the pig.

Preparations:

Pepsinum saccharatum is a mixture of pepsin, as pure as it can be obtained, with milk-sugar. 1 part in 500 parts of water, acidulated with 7½ parts of hydrochloric acid, should dissolve 50 parts of hard-boiled egg-albumen in five or six hours at a temperature of 102° F.: dose, gr. v–ʒj.

Liquor pepsini contains glycerin, hydrochloric acid, water, and saccharated pepsin: dose, fʒij–iv.

Physiological Action.—Pepsin is an easily decomposable nitrogenous body belonging to the class known as ferments; that is, to those substances which are capable of determining or producing changes of the constitution of other bodies without actually acting upon or combining with them. It is normally present in the gastric juice, and is the agent by which animal food is digested. Its action is much assisted by a small amount of acid, and is diminished by alcohol and alkalies.

Therapeutics.—Pepsin is obviously a remedy for derangements of digestion. It is also employed as an addition to nutritive enemata and for injection into morbid growths, non-malignant in character, such as fatty tumors, in which it will produce an arrest of growth and assist absorption. It has been used to dissolve diphtheritic membrane in the throat and blood-clot in the bladder. For these purposes the peptone-pepsin offers the best form. Pepsin should be given shortly after meals.

In dental practice pepsin is employed as an application to putrescent pulps. It has decided antispetic power, and not only assists decomposition, but promotes the disintegration and liquefaction of the pulp-tissues, and thus facilitates the cleansing of the pulp-canals and lessens the liability to the recurrence of putrefactive fermentation. For this use it is made into a paste with distilled water, to which should be added 2 per cent. of hydrochloric acid. It can be freely placed in the pulp-chamber, and should be sealed in the cavity by a gutta-percha stopping, in which should be left an opening for the escape of the gaseous products of the decomposing pulp-tissue. The application should be renewed every twenty-four hours until the pulp is thoroughly disintegrated and the odor of decomposition has ceased. Care must be observed not to continue the application for too prolonged a period, as the hydrochloric acid may produce considerable disintegration of tooth-substance. The

pepsin dressing is more especially of service in acting upon those finer ramifications of the pulp which it is difficult to remove by mechanical means. It has been recommended as an agent for devitalizing teeth in cases in which rapid action is not needed: about $\frac{1}{16}$ of a grain is sufficient. Used alone it does not affect dentine.

Ingluvin is a ferment obtained from the gizzard of the chicken. It is analogous to pepsin, and has been used especially to prevent nausea and vomiting.

Pancreatin is the concentrated ferment of the secretion of the pancreas. It is complex in composition, and has especially the property of emulsifying fats, modifying starch, and forming peptones in *alkaline* solution. Various preparations of pancreatin are now used for the purpose of preparing partially digested food for use in intestinal dyspepsia and in wasting diseases.

Papain (PAPAIVA) is a ferment obtained from the *Carica papaya*, a fruit-tree indigenous to South America. It has active digestive powers on albuminous substances, and has been injected into tumors, and acts readily as a solvent for false membranes, but has not been given internally, owing to apprehension that it may dissolve the gastric mucous membrane.

Acidum Lacticum (LACTIC ACID).—The official acid, containing 75 per cent. of the pure acid ($HC_3H_5O_3$), is a colorless, syrupy liquid derived from the fermentation of milk-sugar: dose, f℈ss to f℥ss, diluted with water.

PHYSIOLOGICAL ACTION AND THERAPEUTICS.—Lactic acid is one of the ingredients of the gastric juice, and hence has been administered in dyspepsia. In certain cases it produces rheumatic inflammation, and for this reason its presence in the blood has been supposed to be the cause of acute rheumatism. It dissolves false membrane, and has been used for this effect in croup and diphtheria. A solution of calcium phosphate in lactic acid is official under the title *syrupus calcii lactophosphatis*, but is not really a combination of the two acids.

Acidum Hydrochloricum (HYDROCHLORIC ACID).—This acid, generally known as muriatic acid, HCl, is a colorless gas, but is always seen in the form of a solution containing about 32 per cent. of the true acid. This solution is colorless, and has a pungent odor and strongly acid properties.

PREPARATION:

Acidum hydrochloricum dilutum: this contains 10 per cent. of the real acid, HCl, in water, and is therefore a little less than one-third the strength of the commercial acid: dose, ♏iij–x.

PHYSIOLOGICAL ACTION.—This acid is, in general terms, the weakest of the so-called mineral acids (nitric, sulphuric, and phosphoric being others of the same group), but they all have a close resemblance in their physiological action: their chemical action differs somewhat. Hydrochloric acid in its concentrated forms is a powerful corrosive, irritant poison, producing violent gastro-enteric inflammation. Like the other mineral acids, it abstracts water from animal tissue, coagulates its albu-

men, and combines with its alkaline constituents, thus effectually destroying not only its form, but its chemical composition. This line of effects constitutes it a true escharotic. The antidotes are baking soda, magnesia, or chalk. Dilute and in small doses, it stimulates the secretions of saliva and bile, but diminishes the flow of the gastric juice.

THERAPEUTICS.—Dilute hydrochloric acid is used in continued fevers, especially of the typhoid type. In common with other mineral acids, it, as already stated, promotes the secretion of alkaline digestive fluids, such as the saliva and bile, and, given before meals, diminishes the outflow of acid secretions, such as the gastric juice, this dual action being the result of their chemical position relative to those fluids respectively, acids promoting the osmosis of alkaline substances and retarding that of acid substances. As hydrochloric acid promotes the digestive power of pepsin, and is a normal constituent of the gastric juice, it is given after meals when its deficiency in that fluid is suspected. It is also administered to lessen phosphatic deposits in the urine.

This acid, and all the other mineral acids, should be administered, much diluted, by sucking through a tube, and rinsing the mouth immediately afterward with an alkaline wash, to avoid injury to the teeth.

Locally, the undiluted acid is a serviceable application in malignant ulcerations of the mouth or throat. In cancrum oris and gangrenous stomatitis is has proved efficient, but the application must be carefully restricted to the tissues involved in the ulcerative action, as the acid is very corrosive, not only coagulating, but destroying, the albumen of the tissues with which it may be brought in contact.

Acidum Nitricum (NITRIC ACID, *aqua fortis*, HNO_3).—The official acid contains 30.6 per cent. of water. It is a colorless fuming liquid, staining the skin yellow, and is strongly escharotic. *Acidum nitricum dilutum* contains 10 per cent. of true acid, HNO_3. It is the form used internally: dose, ♏iij–xv, well diluted.

PHYSIOLOGICAL ACTION.—The effects of nitric acid are in many respects closely allied to those of hydrochloric acid. In strong doses it is a violent poison. Its action upon protoplasm, however, is not quite so violent as that either of hydrochloric acid or of sulphuric or phosphoric acid, albumen being coagulated, but not so rapidly destroyed as by the other members of the group. As the coagulated albumen forms a film more or less firm, the tissues beneath are in a measure protected from the action of the agent. The weaker chemical affinities thus manifested by nitric acid make its escharotic action less violent than that of the other acids above mentioned. The concentrated vapor is intensely irritant to the respiratory passages, and spasm of the glottis or violent inflammation may result from its inhalation. Nitric acid is believed to stimulate the biliary function, and its effect upon the other secretions is much the same as that of hydrochloric acid.

THERAPEUTICS.—Nitric acid is applied externally to destroy warty growths, phagedenic ulcers, cancrum oris, hemorrhoids, and chancres. In dental practice it has been used as an obtundent to sensitive dentine and for the removal of fungous granulations of pulp- and gum-tissue. Internally administered it has been found serviceable in torpidity of the

liver, and in febrile states associated with biliary derangement it makes, when largely diluted, a cooling drink which assuages thirst and promotes the flow of bile. In patients debilitated from the combined effects of syphilis and prolonged mercurialization it often proves remedial. Like hydrochloric acid, it diminishes phosphatic deposits in the urine.

Acidum Sulphuricum (SULPHURIC ACID, *oil of vitriol*, H_2SO_4).—The official sulphuric acid should contain at least 96 per cent. of the absolute acid. It is a colorless, odorless, heavy, oily liquid, and when mixed with water produces much heat. This latter fact must be borne in mind when working with the acid or serious results may ensue. Two preparations are official.

PREPARATIONS:

Acidum sulphuricum dilutum contains 10 per cent. of strong acid: dose, ♏x, *largely diluted.*

Acidum sulphuricum aromaticum (elixir of vitriol) contains 20 per cent. of strong acid, diluted with alcohol and flavored with spices. Ethereal compounds are formed: dose, ♏x, diluted.

PHYSIOLOGICAL ACTIONS.—The strong acid has a powerful affinity for water, and will decompose nearly all organic bodies, abstracting the hydrogen and oxygen and liberating the carbon in the form of charcoal; hence it chars the tissues, turning them black in color, whereas nitric acid stains them yellow. Sulphuric acid, therefore, acts as a powerful escharotic and corrosive irritant poison. When internally given it is excreted by the intestines, the kidneys, and the skin.

THERAPEUTICS.—One of the chief uses of this acid, largely diluted with water, is as an acid drink for painters and those employed in lead-factories or otherwise exposed to lead-poisoning. On theoretical grounds it is assumed to convert into an insoluble sulphate the lead absorbed into the system. Baths of sulphuric acid and water have also been employed for the same purpose. As it is in part eliminated through the mucous membrane, it is thought to be specially useful in passive hemorrhage from these surfaces. In choleraic affections and chronic diarrhœa and dysentery sulphuric acid is much employed, as also in the night-sweats of phthisis, in all of which conditions it exerts tonic and astringent powers. For these uses the aromatic sulphuric acid is found to be an agreeable and efficient form of administration. Locally, the stronger acid may be employed for its escharotic effect upon malignant ulcerations. Mixed with charcoal, it has been applied in the form of a paste to cancerous growths. A combination of the acid with zinc sulphate is also an efficient application, especially in cancrum oris and in gangrene of the mouth, in which latter condition sulphuric acid acts with peculiar efficiency. In the milder forms of stomatitis it may be employed, largely diluted, as an astringent mouth-wash.

In dental practice aromatic sulphuric acid is much employed in the treatment of pyorrhœa alveolaris and as an injection in chronic alveolar abscess. It is especially serviceable in such disorders where there is necrosis of the alveolar walls: thin spiculæ of bone may be dissolved by the acid, and thus a source of irritation be removed, while by the stimulant effect of the application the formation of healthy granulations

will be favored. To be effective in such conditions the aromatic sulphuric acid must be kept in contact with the parts for several hours. Cotton saturated with the application can be packed into pockets, sinuses, or abscesses, and be there retained until its full chemical effect has been exerted. The teeth must be protected by the frequent use of alkaline washes.

Acidum Nitro-hydrochloricum (NITRO-MURIATIC ACID, *aqua regia*).—This is a mixture of 4 parts of nitric and 15 parts of hydrochloric acid. A reaction occurs by which some free chlorine is formed, as may be made clear by the following equation:

$$2HNO_3 + 6HCl = 4H_2O + 2NO + Cl_6.$$

In addition, however, to this action, easily decomposable compounds of chlorine and nitrogen oxide are formed. This mixture is supposed to have a special action on the liver, and when freshly prepared is one of the best forms of the mineral acids for use: dose, ♏v, *largely diluted* when prescribed. A dilute form, made by adding 1 part of the strong acid to 4 parts of water, is official, but it does not keep well.

PHYSIOLOGICAL ACTION AND USES.—The combination of the two acids does not materially modify the effect produced by them singly, either locally or constitutionally, except that upon the biliary secretion a more decided effect is thought to be produced: hence it is chiefly employed, and is doubtless of much efficacy, in hepatic disorders. Given in the form of lemonade in bilious remittent fever, it allays thirst and decidedly diminishes the torpidity of the liver. Its effect in diminishing the gastric secretion must, however, not be forgotten, as its too prolonged use will seriously impair digestion. This effect is not of so much importance during the febrile state, as then the digestive process is almost entirely suspended. In tropical countries, and also in malarial districts in the United States, nitro-hydrochloric acid baths have been employed, either in addition to, or instead of, the internal use of the agent.

Acidum Phosphoricum (PHOSPHORIC ACID, *orthophosphoric acid*, H_3PO_4).—The official acid contains 50 per cent. of H_3PO_4. It is a strongly acid liquid, not as powerful as the other mineral acids, and does not coagulate albumen.

Acidum phosphoricum dilutum, containing 20 per cent. of the strong acid, is official: dose, ♏v–xx, well diluted.

Glacial phosphoric acid (metaphosphoric acid), HPO_3, occurs in translucent masses soluble in water, the solution coagulating albumen immediately, thus indicating its essential difference from H_3PO_4. It, however, is gradually converted into orthophosphoric acid by contact with water.

A concentrated solution of the acid (glacial phosphoric acid), mixed with enough zinc oxide to form a paste, forms the cement so much used as a plastic stopping for carious teeth. (For the formula see Vol. II. p. 251.) Metaphosphoric acid is a test for albumen.

PHYSIOLOGICAL ACTION AND THERAPEUTICS.—Orthophosphoric acid has the same general effects and uses as the other mineral acids.

It, however, does not so much derange digestion, and may be given in larger doses and for longer periods of time when prolonged treatment is required, as in alkalinity of the urine and in diabetes. In the latter disease the dilute acid is specially serviceable in diminishing the excessive secretion of urine and in allaying the thirst which is so distressing a symptom. The dilute acid has also been employed in the night-sweats of phthisis and in catarrhal affections of the lungs. It has been found a serviceable application in caries of the bones, and Coleman highly recommends it as efficient in controlling the discharge and promoting a healthy condition of the cavity in abscess of the antrum. For this use he recommends as an injection 1 part of the dilute acid to 20 of water, the strength to be increased as tolerance is secured by use.

Fixed Oils and Fats.—These are compounds of carbon, hydrogen, and oxygen, the molecular arrangements of which are strictly analogous to the metallic salts and compound ethers; that is, they contain the radicles of certain acids united with hydrocarbons. The majority of fats and fixed oils, although different from each other in properties and exact composition, agree in being the salts of a radicle, C_3H_5 (tritenyl), which form a hydroxide, $C_3H_5(HO)_3$, an alcohol known as glycerin. These fixed oils must be carefully distinguished from the *volatile* or *essential* oils, which are compounds of carbon and hydrogen only, and not in any way similar to the fixed oils.

The fats and fixed oils are not miscible with water, but may be suspended in the form of an emulsion by agitation with solutions of sugars or gums, by the action of pancreatin (*q. v.*), or by the caustic alkalies. The latter effect is due to a decomposition of the fat or oil, by which a soap and glycerin are formed. The digestion of fatty food is accomplished by processes of emulsification analogous to the action just mentioned, the secretions of the liver and pancreas being especially concerned in such action. The principal official members of this group are—

Oleum theobromæ, cacao butter, concrete oil of the kernels of the *Theobroma cacao*, the chocolate tree.

Oleum olivæ, from the fruit of the *Olea Europæa*.

Oleum gossypii seminis, from the seeds of the cotton-plant, *Gossypium herbaceum*.

Oleum morrhuæ, from the liver of the cod, *Gadus morrhuæ*.

Adeps, lard, and *sevum*, suet, are well-known fats.

Physiological Actions and Therapeutics.—Some of the oils and fats are known articles of food, and serve not only to build up the tissues, but to furnish a source of nervous and muscular force. Cod-liver oil has special therapeutic value on account of its accessory ingredients, iodine, bromine, and biliary principles, which latter are found greatly to promote, indeed to be necessary to, the absorption of fats. The local use of the bland oils is resorted to to protect the skin in various inflammatory diseases, and the use of the fats as a vehicle for various medicinal substances is well known. Since most of the bodies of this class are liable to decomposition, by which free acid, irritating and offensive, is produced, it is usual to add to ointments a small amount of benzoic acid as an antiseptic.

Chronic wasting disorders, especially phthisis and scrofulous affections, are among the diseases treated by the use of the oils and fats, cod-liver oil being superior to the others in therapeutic power, probably chiefly by reason of the biliary principles which it contains, these rendering it much more readily absorbable than are other fatty substances when taken by the stomach.

Lanolin.—As a substitute for ordinary fat for local use a preparation of the natural fat of wool has been introduced. It is believed to be more nearly analogous to the natural fat of the skin, and hence to be more freely absorbed from that surface. It is preferred as a vehicle for remedies which are to be absorbed through the skin, but has no advantage over other fats when a merely protective effect is desired.

Phosphorus exists almost entirely as a phosphate, especially calcium phosphate, which enters largely into the structure of bones and teeth. The element is a soft, waxy, translucent, highly inflammable substance, burning with brilliant white flame and giving off phosphoric anhydride in the form of white vapors. In the dark it is a luminous body. To preserve it from oxidation it is kept under water, in which it is insoluble. It is sparingly soluble in fatty oils, ether, and alcohol, and freely soluble in carbon bisulphide. Phosphorus is a powerful irritant poison, death having occurred from a small fraction of a grain. An allotropic non-poisonous form is known. The dose of the active form is gr. $\frac{1}{100}$ to $\frac{1}{20}$.

Antidotes.—In phosphorus-poisoning an active emetic, such as copper sulphate, should be given to empty the stomach, after which hydrated magnesia or lime-water should be administered to retard its action on the tissues. Common oil of turpentine in emulsion, which has been well oxidized (ozonized) by long exposure to the air, has been found to possess antidotal power in both chronic and acute phophorus-poisoning. It is thought to act by preventing the combustion of phosphorus in the blood by union with the oxygen of the tissues. It may be given in emulsion with hydrated magnesia. Workers in phosphorus wear around their necks open vials containing turpentine, the vapors of which they thus constantly inhale—an expedient which is said to secure exemption from the toxic effects of the agent. Oils and fats promote the action of phosphorus, and are therefore to be avoided.

Phosphorus forms a number of acids: among these are phosphoric and hypophosphorous acids, which, together with some of the salts, are official.

PREPARATIONS:

Pilulæ phosphori—each contains $\frac{1}{100}$ gr. of phosphorus.
Oleum phosphoratum contains 1 per cent. of phosphorus in almond oil: dose, ♏j–iij.
Sodii phosphas, $Na_2HPO_4 12H_2O$: dose, ʒj–℥j.
Sodii pyrophosphas: $Na_4P_2O_7 10H_2O$: dose, ʒss–℥ss.
Potassii hypophosphis, KH_2PO_2: dose, gr. v–x.
Sodii hypophosphis, $NaH_2PO_2H_2O$: dose, gr. v–x.
Calcii phosphas præcipitatus, $Ca_3(PO_4)_2$: dose, gr. ij–x.
Calcii hypophosphis, $Ca_4(PO_2)_3$: dose, gr. ij–v.
Syrupus calcii lactophosphatis: dose, fʒj–f℥j.

Physiological Action.—In poisonous doses phosphorus produces symptoms of gastro-intestinal inflammation. It causes copious eructations of hydrogen phosphide; sometimes blood is vomited and convulsions and coma ensue. Should absorption of the poison occur, the liver, stomach, kidneys, and arterial walls will undergo fatty degeneration and the red blood-globules a process of disintegration, deep jaundice and profuse hemorrhages from all mucous surfaces ensuing as the result of these structural changes. Workmen exposed to the inhalations of phosphorus fumes, such as makers of lucifer matches, are liable to necrosis of the maxillary bones, the lower jaw being more frequently attacked than the upper. This is thought to be due to direct local action of the phosphorus upon the tissues of the jaw. It is claimed that only those having carious teeth are liable to the disease. Phosphorus does not produce its active physiological effects by being converted into phosphoric acid or phosphites, for these substances can be given in moderate doses without any irritant effect.

In medicinal doses of phosphorus the heart is stimulated to increased activity, and there is an increase of nervous energy and of intellectual and muscular power.

Therapeutics.—Phosphorus is used in obscure diseases of the nervous system, in nervous exhaustion, in decay of mental power, in defective general nutrition, and in pernicious anæmia. It is occasionally employed as a substitute for arsenic in the treatment of skin disease. The phosphates and hypophosphites are favorite remedies in the treatment of wasting diseases or those in which malnutrition is a feature—rachitis, phthisis, anæmia. The hypophosphites are supposed to fulfil nearly the indications of phosphorus itself. In medical practice phosphoric and hypophosphorous acids are combined with a great variety of vegetable and mineral tonics for special indications. The laxative effect of sodium phosphate is occasionally utilized: dose, as a laxative, ℥ss. Calcium phosphate, though insoluble in water, is dissolved without decomposition by lactic and hydrochloric acids; hence it may be taken up in the stomach to a limited extent and pass directly into the blood. Forming as it does the mineral basis of the bones and teeth, it is obvious that it is indicated in all diseases in which defective development of these structures exists. It appears also to be of value in all the affections characterized by malnutrition. The official solution in lactic acid, wrongly called a lactophosphate (no chemical combination between the lactic and phosphoric acids occurs), is a good form for use.

Phosphates are ingredients of the majority of foods, animal and vegetable. In a vigorous condition of the digestive organs a sufficient amount of phosphorus for the system will be taken up by the normal digestive action.

Ferrum (Iron).—Iron has been employed in medicine from a remote period. The official preparations are very numerous: some are not intended for internal use, and will be omitted. It is important to note that some preparations are *ferrous* and others *ferric* salts.

Preparations:

Ferrum reductum: metallic iron in a fine powder, obtained by the reduction of ferric oxide by hydrogen: dose, gr. j–v.

Massa ferri carbonatis (Vallet's mass) contains ferrous carbonate, $FeCO_3$, with honey and sugar, to prevent oxidation: dose, gr. iij–v.

Pilulæ ferri composita, similar in preparation to the preceding: dose, 2–4 pills.

Tinctura ferri chloridi, an alcoholic solution of *ferric* chloride, Fe_2Cl_6: dose, ♏v–xx.

Syrupus ferri iodidi, FeI_2, a solution of *ferrous* iodide in syrup, to prevent oxidation: dose, ♏v–xx.

Syrupus ferri bromidi, $FeBr_2$, contains *ferrous* bromide: dose, ♏v–xx.

Ferri sulphas, ferrous sulphate, green vitriol, $FeSO_4 + 7H_2O$, used largely as a disinfectant. In the dried form (deprived of water of crystallization) it is used internally in doses of gr. ss–ij.

Liquor ferri subsulphatis, Monsel's solution, or ferric oxysulphate, $Fe_2(SO_4)_2O$, the normal sulphate being $Fe_2(SO_4)_3$. Monsel's solution is principally used as a styptic.

Liquor ferri nitratis, $Fe_2(NO_3)_6$: dose, ♏v–xv.

Ferri hypophosphis, ferric hypophosphite; *Ferri phosphas*, ferric phosphate; *Ferri pyrophosphas*, ferric pyrophosphate,—these three preparations are intended to combine the tonic blood-producing properties of iron with the general nutritive value of the phosphates. The dose of each is about three grains.

There are a large number of double salts of iron with organic acids, such as iron-quinine citrate, potassio-ferric tartrate, but their effects and uses do not differ from the extemporaneous combination of their ingredients. The preparations enumerated above will suffice to meet all the therapeutical indications of iron.

Physiological Action.—Iron is an ingredient of many tissues, among others the red corpuscles of the blood, and when administered assists in increasing the number of these corpuscles and in promoting the appetite. It is also found in the bile, chyle, gastric juice, and milk, and in the eye and hair as a pigment. Large doses are irritating, and many of the liquid or highly soluble preparations act destructively on the teeth. Locally, many of the iron salts are astringent and styptic. The chloride, sulphate, iodide, and nitrate are irritant poisons. The precipitated ferric oxide is non-poisonous. Iron salts are incompatible with vegetable astringents, alkalies, and carbonates. Its preparations should be given in minimum dose and not too long continued. Only small quantities of iron are absorbed.

Therapeutics.—Iron is chiefly used in the treatment of anæmia. It is given after meals, and must be occasionally suspended to avoid deranging the stomach. It is especially necessary, in using the liquid preparations, to avoid injuring the teeth. The injurious action is principally observed with the tincture of the chloride, which is a much-used preparation. When this is diluted with water a decomposition may ensue by which free hydrochloric acid will be formed and ferric oxide precipitated. In this the preparation becomes still more injurious. It appears, from some recent observations, that dilution should be either with alcohol, some carbonated mineral water, or with syrup. The use of a tube or straw, inserted well back in the mouth, the iron solution being well diluted and the mouth being subsequently rinsed out with an alkaline wash, is some protection. Neither the reduced iron nor the carbonate in pill form is injurious to the teeth, but their ingestion is said to be liable to produce eructations of hydrogen compounds.

The tincture of the chloride is largely used for internal administration as a general tonic and in certain prostrating germ diseases, such as erysipelas and diphtheria, and in internal hemorrhage. The astringent preparations, especially the nitrate, are used in diarrhœa and dysentery.

The precipitated ferric hydroxide, $Fe_2(HO)_6$, produced by adding any alkali or alkaline carbonate to any of the red salts of iron (*e. g.* tincture of the chloride or Monsel's solution), is in a fresh condition an antidote to arsenious oxide. It is a soft reddish-brown mass, and may be given freely—in teaspoonful doses—as it is not poisonous. It forms with the arsenious oxide an insoluble compound, but one which must not be allowed to remain in the stomach, as it will in time undergo decomposition and the arsenic be absorbed.

Ferric subsulphate, both in solid form and in solution, has been extensively used as a styptic in oozing hemorrhages, such as sometimes occur after tooth-extraction, the salt producing dense dark-colored clots. This application, however, is liable to cause sloughing of the bleeding tissue, and the use of such powerful agents is not now in favor. If the subsulphate is used at all on the gums and alveoli, it should be employed cautiously and not in strong solution.

Manganum (MANGANESE).—This metal is analogous to iron.

PREPARATIONS:

Mangani oxidum nigrum, MnO_2: dose, gr. ij–x.
Mangani sulphas, manganous sulphate, $MnSO_4+4H_2O$: dose, gr. ij–v.
Potassii permanganas, $K_2Mn_2O_8$: dose, gr. ss–ij.

Potassium permanganate occurs in the form of slender prismatic crystals, deep purple in color, which yield large amounts of oxygen readily; hence it is used as an oxidizing agent. It cannot be mixed with organic matter without being decomposed, but it may be put up in the form of pellets, either alone or with some inert mineral like kaolin.

PHYSIOLOGICAL ACTION AND THERAPEUTICS.—Manganese is associated with iron in the blood and other fluids of the body, but is present in very minute quantity. As small doses improve the appetite and digestion and stimulate the circulation, it has been recommended as a tonic, and is sometimes used as synergistic to iron. The oxide and potassium permanganate have been introduced lately as remedies for amenorrhœa. Potassium permanganate is much in favor as a deodorizer and disinfectant, which properties it possesses by virtue of the fact that the oxygen which it yields destroys organic matter. This property makes it an effective antidote for the poison of venomous serpents if a strong solution be promptly injected into the wound. The chief use of the permanganate is in surgical practice, where it is applied as a wash to foul and ill-smelling surfaces or to deodorize fetid discharges, as in cancer, ozæna, septic abscesses, gangrene, etc.

In dentistry it is applied to analogous uses, and is of service in correcting fetor of the breath, especially when associated with unhealthy discharges from the teeth and gums. For this purpose a solution containing from one to two grains to the ounce of water may be employed. In abscess of the antrum it is very efficient as a deodorizer. It has also been applied (grs. x to aqua f℥j) to the treatment of putrescent pulps and as a dressing in pyorrhœa alveolaris; but for these uses other oxidizing agents, such as hydrogen dioxide, are preferable. The oxidizing action of potassium permanganate is indicated by its becoming brown or colorless. It stains the skin brown, but this discoloration can be removed by dilute hydrochloric acid.

Bismuthum (Bismuth).—Two insoluble oxy- or so-called sub-salts of irregular composition are, in addition to a soluble double salt, used therapeutically.

Preparations:

Bismuthi subcarbonas, $(BiO)_2CO_3H_2O$, a white insoluble powder: dose, gr. x–ʒj.

Bismuthi subnitras, approximately $BiNO_3O$, a white powder, often strongly crystalline: dose, gr. x–ʒj.

Bismuthi et ammonii citras, soluble in water: dose, gr. j–v.

Physiological Action and Therapeutics.—Bismuth is principally used for its sedative local action. It has feeble tonic and astringent powers if absorbed. Bismuth salts are partly converted into sulphide in the stomach and intestine. The insoluble salts are used in diarrhœa, dysentery, gastralgia; also in gonorrhœa and gleet. They are given in large doses, and the subcarbonate is to be preferred to the nitrate, as it is smoother. Locally, bismuth is advantageously employed in various skin diseases, such as eczema, and also in aphthæ and stomatitis.

Arsenium (Arsenic).—Arsenic (As) is an element intermediate in character between the true metals and the non-metals, and might properly be called a metalloid. The term "arsenic" is frequently applied to one of the oxides, As_2O_3 (mistakenly called "acid"), and care must be taken not to confuse these uses of the word. The element, as such, has no application in therapeutics. With scarcely any exception its compounds are powerful irritant poisons. It forms two distinct series of compounds, distinguished by the terminations *ous* and *ic;* thus, As_2O_3, arsenious acid (oxide); As_2O_5, arsenic acid (oxide). Its compounds are strictly analogous to those of nitrogen, phosphorus, and antimony.

Preparations:

Acidum arseniosum, arsenious acid, arsenious oxide, white arsenic, As_2O_3. This well-known substance is strictly not an acid, but an anhydride; that is, a body which by union with water will produce an acid. It is a heavy white powder, usually distinctly crystalline, volatile at a moderate heat, but slightly soluble in water, but much more freely in dilute acid or alkaline solutions: dose, gr. $\frac{1}{30}$–$\frac{1}{10}$.

Liquor acidi arseniosi, a 1 per cent. solution of the oxide in water with hydrochloric acid: dose, ♏ij–x.

Liquor potassii arsenitis, solution of potassium arsenite, Fowler's solution: dose, ♏ij–x.

Sodii arsenias, sodium arsenate, $Na_2HAsO_4+7H_2O$. This is a compound of the higher oxide (As_2O_5). It is a soluble crystalline salt: dose, gr. $\frac{1}{20}$–$\frac{1}{10}$.

Liquor sodii arseniatis is a 1 per cent. solution of the above: dose, ♏ij–x.

Liquor arsenii et hydrargyri iodidi, Donovan's solution, 1 per cent. of each iodide in water: dose, ♏ij–x.

It should be noted that Fowler's solution and Donovan's solution contain derivatives of arsenious oxide, As_2O_3, while the sodium arsenate is derived from the arsenic oxide, As_2O_5.

Physiological Action.—Locally applied to the raw skin, arsenious acid acts as an escharotic, and if a considerable quantity is used it produces sufficient inflammation to block up the vessels and prevent absorption. If applied in dilute solutions over a large surface, it will act as a poison by absorption. Given internally, in small doses, it acts as a tonic, improving the appetite; and in some cases a tolerance of it may be established, so that large doses can be taken. Its use in full medi-

cinal doses gives rise to puffiness of the face and eyelids (œdema arsenicalis), epigastric pain, nausea, vomiting, diarrhœa, skin eruptions, and ultimately a condition of chronic poisoning which may prove fatal. The cerebral functions are not noticeably affected.

Large doses—two grains or more—produce a high grade of gastro-enteric inflammation, with violent vomiting and purging, fever, great pain, rapid and feeble pulse, finally exhaustion and collapse; in short, the typical symptoms of irritant poisoning. These effects have been noticed even when the arsenic was not introduced by the stomach. Rarely—perhaps more especially when the dose is very large, half an ounce or more—no irritation is produced, but a condition of coma which continues until death. Chronic arsenical poisoning occurs from the introduction by inhalation of arsenical fumes or dust. Arsenical poisoning is treated by the use of ferric hydroxide, $Fe_2(HO)_6$, commonly called hydrated sesquioxide of iron, which must be prepared as needed by treating a solution of some of the red salts of iron (ferric salts) with either ammonia-water or sodium carbonate and washing the soft pulpy mass with water, and then administering it freely. Dialyzed iron mixed with salt may also be used. Oil, milk, and mucilaginous drinks should be given.

Therapeutics.—Arsenious acid has been much used externally as a paste to destroy malignant growths. It is not, however, employed for this purpose in regular practice. Its local use as a devitalizer for the dental pulp is referred to below. Internally it is employed in dyspepsias, affections of the respiratory organs, and in neuralgias, especially those due to malarial impression. In the treatment of chronic malarial troubles it is of great value. It is also employed in anæmia, chronic rheumatism, and chronic skin affections. Hypodermically it has been used with success in chorea.

In the internal administration of arsenic Fowler's solution is generally employed, and it is preferable to begin with the full dose, ten minims, and gradually decrease it, giving always on a full stomach. By this means the remedy can be continued for quite a prolonged period and without dangerous symptoms.

Use in Dental Practice.—In dental practice the use of arsenious acid is chiefly confined to devitalization of the dental pulp, a method first employed by Dr. J. R. Spooner of Montreal about the year 1836. Dr. Spooner at first used arsenious acid alone, but subsequently he recommended a mixture composed of arsenious acid 3 parts and morphine acetate 1 part, and claimed to be able to produce with it the painless death of the pulp. Since then large numbers of formulæ have been proposed to accomplish this result, but none thus far employed have proved invariably successful; indeed, many practitioners have returned to the original method and use the drug without admixture. One of the most recent and successful combinations is that of arsenious acid and cocaine, as in the following formula by Dr. E. C. Kirk:

Take of Arsenious acid in fine powder,
Cocaine hydrochlorate, each gr. xx;
Menthol, cryst., gr. v;
Glycerin enough to make a stiff paste. M.

Dr. Kirk states that he has been very successful with this application, but has not invariably succeeded in making devitalization a painless process.

As already noted in the summary of the physiological action of the drug, the administration of arsenic by the stomach sometimes produces gastro-intestinal inflammation; in other cases these symptoms are absent, and the nervous system appears to be primarily and chiefly affected. These phenomena are also observable on application to the dental pulp. In some cases it acts as a caustic, producing violent pain and inflammation, followed by a surface slough, generally with, but sometimes without, death of the pulp. In other cases the nerve-tissue of the pulp is almost immediately devitalized, without pain or appreciable irritation.

This dual action of arsenic appears to be dependent upon and determined by both local and systemic conditions. Congestion of the pulp-capillaries due to pre-existent inflammation retards the absorption of arsenious acid and thus limits its influence to the surface tissue, upon which it acts chemically; in consequence of which action pain results as nerve-tissue is secondarily affected. Hence the indication to relieve congestion or hyperæmia before making the application.

Constitutional peculiarities also modify the effect of arsenic locally applied. Persons of the lymphatic temperament, of low vital power, and with an excess of fluids in the tissues succumb readily, absorption is rapid, and pulp-devitalization speedy and comparatively painless. The reverse is true of those highly endowed with nerve-force or in whom there exists excessive nervous irritability. In the latter class of cases pulp-devitalization with arsenic is often extremely difficult, and sometimes impossible of accomplishment.

To secure painless devitalization the avoidance of pressure upon the exposed pulp is of capital importance. This is often best secured by placing upon the exposed point a minute portion of arsenious acid (gr. $\frac{1}{60}$) taken up upon a pinhead pledget of cotton-wool dipped in oil of cloves, and protecting the dressing and pulp by covering them with a concave disk of thin platinum, afterward closing the carious cavity with a suitable stopping of soft gutta-percha.

Another important consideration is to avoid the contact of the arsenious acid with the gum-tissue. This, in proximal cavities, may occur either through displacement in applying the dressing and sealing the cavity, or by leakage from the cervical margin of an imperfectly adapted stopping.

In this class of cavities a good plan is to pack base-plate gutta-percha against the gum-margin next to the carious cavity, thus almost entirely filling the interspace and shutting off all possibility of contact of the arsenic with the gum-tissue. The arsenic can then be applied and the cavity closed in the usual way. When such precautions are observed the application is usually comparatively painless.

Failure to confine the arsenical application to the cavity of the tooth may not only result in pain, but often in the most violently destructive inflammation, which may involve the alveoli and even extend to the maxillary periosteum, with resulting necrosis and possible death from septic poisoning.

In persons of the strumous cachexia analogous results have been known to follow too large a dose or one too long retained in the tooth. There is more danger of this complication when the tooth is newly erupted than at a later period when it is fully formed. At the present day trouble from this source is of rare occurrence—an exemption probably due, in part, to the greater care with which such applications are made, but also to the smaller amounts of the drug which are now employed. By using the smaller dosage the whole process is made much safer as well as much less painful, although complete devitalization may not be so rapidly effected.

(For a further study of the practical relations of arsenious acid to dental practice the reader is referred to Vol. I. p. 899, and Vol. II. pp. 172 *et seq.*)

SIMPLE BITTERS.

A number of simple bitters are official, the physiological action and therapeutics of which are substantially similar. They contain no tannin, and are destitute of astringent or aromatic properties.

Quassia is the wood of the *Picræna excelsa*, a West Indian tree. It contains a crystalline bitter principle, *quassin*, slowly soluble in water. The wood is sometimes used in the form of cups, in which the water is allowed to stand for a short time before drinking.

PREPARATIONS:
- *Extractum quassiæ:* dose, gr. j–iij.
- *Extractum quassiæ fluidum:* dose, f℥ss–j.
- *Tinctura quassiæ:* dose, ♏v–f℥j.

PHYSIOLOGICAL EFFECT.—Quassia is a simple bitter, without aromatic or astringent action. It stimulates the flow of saliva and gastric juice, and thus aids the digestive function. It is employed as a substitute for hops in the preparation of malt liquors. In large doses it is not entirely free from danger.

THERAPEUTICS.—Quassia is used in atonic dyspepsia accompanied with pain and regurgitation of food after eating; it is also employed in diarrhœa and as a general stomachic tonic.

Gentiana (GENTIAN).—This well-known bitter tonic is the root of the *Gentiana lutea*, an herb of the mountainous regions of Europe. It contains a crystallizable principle, *gentianin*, soluble in water, but no tannin.

PREPARATIONS:
- *Extractum gentianæ:* dose, gr. j–v.
- *Extractum gentianæ fluidum:* dose, f℥ss–j.
- *Tinctura gentianæ composita:* dose, f℥ss–ij.

PHYSIOLOGICAL ACTION AND THERAPEUTICS.—These are similar to those of quassia. Gentian is an ingredient in many of the so-called "nerve-tonics" so much advertised.

Calumba (COLUMBO) is the root of the *Jateorrhiza calumba*, a South African plant. It contains a bitter principle, *calumbin*, and an alkaloid, *berberine*.

PREPARATIONS:
- *Extractum calumbæ fluidum:* dose, ♏v–xxx.
- *Tinctura calumbæ:* dose, f℥ss–ij.

PHYSIOLOGICAL ACTION AND THERAPEUTICS.—These are substantially the same as those of quassia. Berberine is a feeble antiperiodic.

Chirata, an East Indian herb, is also a member of this class. A fluid extract and tincture are official, the dose of which is similar to the analogous preparations of gentian and columbo.

AROMATIC BITTERS.

Serpentaria is the root of the *Aristolochia serpentaria*, Virginia snakeroot. It contains a volatile oil and a soluble bitter principle.

PREPARATIONS:
Extractum serpentariæ fluidum: dose, ♏x–xxx.
Tinctura serpentariæ: dose, f℥ss–ij.

PHYSIOLOGICAL ACTION AND THERAPEUTICS.—Serpentaria is a stimulant expectorant and tonic, increasing the heart's action and promoting the cutaneous circulation and the secretions of the intestinal and bronchial mucous membranes; it also produces some cerebral excitement. Large doses are irritant, causing diarrhœa, nausea, headache, and vertigo. It is largely employed as a vehicle for other drugs, as for cinchona in the compound tincture of that agent.

Serpentaria is used as an expectorant in bronchial affections and as a stimulant in typhoid pneumonia, and, combined with ammonium chloride, in typhoid conditions generally; it is also given in chlorosis and anæmia. Locally, it is used as a gargle in diphtheritic affections, and is one of the numerous remedies for the treatment of rhus-poisoning.

The following are several aromatic bitters analogous in effects and uses to serpentaria.

Anthemis (CHAMOMILE), the flowers of the *Anthemis nobilis*, a stimulant tonic, increasing digestion, exciting a sensation of warmth in the stomach, and increasing its blood-supply. It is much employed in domestic practice to relieve flatulent colic and various infantile disorders attended by digestive derangement. A warm infusion is sometimes used as an emetic. Fomentations made with hot water and vinegar are used for the relief of pain in various parts of the body; sometimes they are applied to the face in toothache, but in this case the danger of causing an abscess to point outwardly must be borne in mind.

Matricaria (GERMAN CHAMOMILE).—The flowers of the *Matricaria chamomilla*, similar to *Anthemis* in its effects and uses.

Eupatorium (BONESET), leaves and tops of the *Eupatorium perfoliatum*. It is used as a stimulant diaphoretic in fevers.

Eucalyptus is the leaves of the mature tree of the *Eucalyptus globulus*. They contain tannic acid and a complex volatile oil analogous to camphor, among the constituents of which is *eucalyptol*, $C_{12}H_{20}O$.

PREPARATIONS:
Extractum eucalypti fluidum: dose, ♏x–f℥j.
Oleum eucalypti: dose, ♏v–xxx.

Physiological Action.—Eucalyptus was originally proposed for cultivation on marshy districts as an antimalarial agent—a claim which has not been substantiated by trial. Its preparations in small doses stimulate the digestive secretions, promote appetite, and increase the action of the heart. In large doses it causes gastro-enteric irritation, muscular weakness, and respiratory paralysis.

The antiseptic and germicide action of eucalyptol, the volatile oil, is the most important property. It is powerfully destructive to low forms of organic life, and therefore an ingredient in many of the germicides and antiseptic soaps and dressings now used.

Therapeutics.—Eucalyptus is employed in chronic catarrhal troubles, especially of the bladder, in atonic dyspepsia, and in catarrhal disorders of the intestines. It is of use as a substitute for cinchona in the treatment of chronic malarial conditions. Locally, the fluid extract is employed in dilute solution as a disinfecting dressing for ulcers and wounds; also in stomatitis, pharyngitis, and tonsillitis, and offensive ulcerations of the mouth.

In dental practice the antiseptic powers of the oil of eucalyptus are of great value in the treatment of putrescent pulps, and as injection in chronic alveolar abscess or pyorrhœa alveolaris, for which uses it is often combined with other antiseptics, as carbolic acid, oil of winter-green (equal parts of each). It is frequently used in conjunction with iodoform, which is too sparingly soluble in it to enter into solution, but which can be rubbed up into a paste with the oil, the odor of the iodoform being thus somewhat disguised, while its antiseptic powers are perhaps increased. As a dressing to putrescent pulp-canals a better mixture is one extemporaneously made by dipping a pledget of cotton in the oil and then in finely pulverized iodoform (Truman), which will adhere closely to the cotton thus prepared, and can thus be readily placed in position in the tooth.

Hydrastis (Golden Seal).—Hydrastis is the rhizome of the *Hydrastis Canadensis*. It contains several organic principles, among which are two alkaloids, *hydrastine* and *berberine*.

Preparations:

Extractum hydrastis fluidum: dose, ♏v–xx.
Tinctura hydrastis: dose, f℥ss–ij.

Physiological Effects.—Hydrastis increases the digestive secretions and possesses marked antiperiodic powers. By its action as a protoplasmic poison it arrests the movements of the white blood-corpuscles. The alkaloid, hydrastine, is somewhat similar to quinine in its effects on the nervous system, but is not capable of producing such marked tonic effects. The plant is more active. The vegetable astringents and alkalies are incompatible with hydrastis.

Therapeutics.—Hydrastis is a tonic, antiperiodic, and antiseptic. It is used in malarial fevers and in inflammations of mucous surfaces, both chronic and acute, and is employed locally as well as internally in these affections. It is applied to ulcers, fissures, and abrasions of the mucous or muco-cutaneous surfaces, and is useful as a local antiseptic application (tincture, fʒj; aqua, f℥j) in ptyalism and all indolent and offensive ulcerations of the mouth and throat.

Cinchona (Peruvian Bark).—Under this name are included the barks of a number of trees of the genus *Cinchona*, belonging to the natural order *Rubiaceæ*. Two varieties specially designated are official: *Cinchona flava*, yellow bark, obtained from the *C. calisaya*; *Cinchona rubra*, red bark, obtained from the *C. succirubra*.

All forms owe their activity to a number of crystallizable well-marked alkaloids closely similar in properties and composition. The more important of these are quinine, cinchonine, quinidine, and cinchonidine. The U. S. Pharmacopœia limits the official bark to those containing not less than three per cent. of total alkaloids, including two per cent. of quinine. Preparations of the barks, and even the powdered bark itself, were formerly used, but the alkaloids, especially as sulphates, are now principally employed.

Preparations of the Barks:

Extractum cinchonæ: dose, gr. j–v.
Extractum cinchonæ fluidum: dose, ♏x–f℥j.
Tinctura cinchonæ: dose, fʒss–j.
Tinctura cinchona composita: dose, fʒj–iv.
Infusum cinchonæ: dose, fʒ–℥j.
Huxham's tincture, now not official, contains serpentaria and carminatives, and is still much used: dose, fʒj–ij.

Quinina (*quinine*), $C_{20}H_{24}N_2O_2 + 3H_2O$, the principal alkaloid of cinchona, is a crystalline powder, very bitter, but slightly soluble in water. It easily forms salts with acids, of which several are official: dose, gr. j–xx, or even higher.

Quininæ sulphas, $(C_{20}H_{24}N_2O_2)_2H_2SO_4 + 7H_2O$.—This, the most familiar salt of quinine, is not very soluble in water, and hence in prescriptions it is usual to add a small amount of sulphuric acid: dose, gr. j–to xxx or higher.

Quininæ bisulphas, $C_{20}H_{24}N_2O_2.H_2SO_47H_2O$.—This is employed on account of its much greater solubility in water: dose, gr. j–xxx.

Quininæ hydrobromas, $C_{20}H_{24}N_2O_2.HBr.2H_2O$, is preferred for hypodermic use, about four grains in one drachm of water being used for this purpose: dose, internally, gr. j–xx.

Quinine and Urea Hydrochlorate.—This double salt is not official, but has recently come into favor as a form for hypodermic use in doses of one to three grains. It is almost unirritating.

Quininæ hydrochloras and *Quininæ valerianas* are also official.

Cinchonine and its sulphate, cinchonidine sulphate, quinidine sulphate, and chinoidin, an amorphous mixture of the alkaloids,—are all official, but offer no special characteristics.

Physiological Action.—The systemic effect of quinine may be taken as typical of that of cinchona-bark. The latter, however, is more astringent and more irritating to the stomach. Taken into the stomach in small doses, quinine improves the appetite and has tonic powers, but in large or long-continued doses it may cause irritation. Its direct effect upon the secretions is not known, but it is not believed to have any specific influence in stimulating the action of the liver, any effects of this nature which may follow its use being due to its power over the morbific influences, such as the malarial poison, upon which hepatic torpor so frequently depends.

The circulation is stimulated by small doses, depressed by large, and arrested by toxic doses as the result of cardiac paralysis, in which arrest of functional power the respiratory centre also participates. The reflex action of the spinal cord is diminished. In full doses a condition known as cinchonism is produced, the most marked effects being a sensation of tightness across the forehead, giddiness, vertigo, ringing in the ears (tinnitus aurium), and some temporary impairment of the power of hearing. By excessive use permanent deafness may be induced: this, however, is of very rare occurrence. Tissue-changes are retarded by full doses of quinine, and in fevers the temperature is lowered—an effect which does not follow its use in health. Quinine is a protoplasmic poison, and by large doses the amœboid movements of the white blood-corpuscles are arrested. It is destructive to many low animal and vegetable organisms, and hence is an antiseptic of considerable power, and in sufficient volume is capable of arresting not only putrefactive decomposition, but other allied processes depending on the action of organized ferments, such as the alcoholic, lactic, and butyric fermentations.

The elimination of quinine from the system takes place slowly, and chiefly by the kidneys, which are generally stimulated to increased activity by its presence in the blood. It appears in the urine within half an hour of its administration, but the full elimination of the drug requires nearly two days, although the greater portion will have been excreted in twelve hours. Five hours are required for the production of the maximum effects of a full dose of quinine.

Therapeutics.—The chief use of preparations of cinchona-bark is as an astringent bitter tonic for the treatment of atonic dyspepsia, gastric catarrh, and allied disorders. The compound tincture is especially serviceable in the digestive debility of convalescence from typhoid fever. The powdered bark enters into many of the formulæ for dentifrices, in which it is of doubtful value, and the infusion and tincture have been largely employed as astringent and antiseptic mouth-washes and gargles for spongy gums and ulcerations of the mouth and fauces.

Quinine.—Owing to its germicidal effect, quinine may be employed as an antiseptic. In hay fever, believed to be due to the irritant effect of the pollen of grasses upon the mucous lining of the nose, a solution of the quinine hydrochlorate in water (gr. v to f℥j), thrown into the nostrils by a suitable syringe or douche, will often be of service: success, however, is not by any means invariable. A similar solution, given in the form of spray in whooping cough, has also proved effective.

Internally, quinine is largely used as a tonic, very often in combination with iron; but it is in malarial diseases that it finds extended use. It may be regarded as a specific in intermittent and remittent fevers. In these it should be used in full doses, at least ten grains, and in the more pernicious forms thirty-grain doses are often required. In chronic malarial poisoning chinoidine is said to be preferable, and arsenic is also employed. Neuralgias of malarial origin, and especially neuralgias of the fifth pair of nerves, are amenable to quinine, and it is used in the whole course of the eruptive fevers, chiefly as an antipyretic. In the treatment of typhoid or typhus fever, unless there be a malarial

complication, quinine is useless, and, owing to its irritant effect upon the inflamed digestive tract, often positively injurious. In septic diseases, such as pyæmia, erysipelas, puerperal fever, and septicæmia, it renders important service, reducing the temperature and probably retarding the proliferation of septic organisms. In erysipelas quinine is specially serviceable, both for internal use and local application to the seat of the disease. For the latter purpose it is well to combine it with tincture of chloride of iron (quinina, ʒj; tinct. ferri chloridi, f℥j), applying it freely to and beyond the margins of the erysipelatous surface two or three times daily.

Many practitioners rely upon quinine in the treatment of pneumonia and pleuritis, and the inflammatory process may be arrested by full doses if given in the inception of the disease. In acute catarrh also quinine is very effective. In all this class of cases better results will be obtained by a combination of the quinine with morphine or some active preparation of opium.

In dental practice also quinine is serviceable in combating inflammation, especially of the peridental membrane. Good results from its use can be hoped for only in the early stages of the disease, before effusion of inflammatory products, cell-proliferation, and migration of the white blood-corpuscles have taken place. It must be given promptly and in full doses, six to ten grains, twice in twenty-four hours, and, as in the other inflammations previously mentioned, the treatment will be more effective if the quinine is given in conjunction with opium, local depletion being at the same time not neglected. (See Vol. I. p. 928.) Active remedial measures of this character, even if they do not prevent suppuration, will lessen the violence and extent of the inflammatory process, diminish suffering, and reduce the dangers of septicæmia. The treatment should for this reason be continued until the abscess has fully formed and been fully discharged.

As already stated, quinine is an efficient remedy in neuralgias of the fifth nerve, especially when they are malarial in type. In a paper on the "Effects of Malarial Poisoning in the Dental Pulp" (*Dental Cosmos*, Oct., 1883), Dr. J. A. Klump calls attention to the fact that in cases of hypersensitiveness of tooth-structure "three or four-grain doses of quinina given every four hours until about thirty grains have been administered in anticipation of the sitting will not only allay the sensibility of the dentine, but produce such a quieting effect on the general nervous system that operations can then be performed with satisfaction to patient and operator."

AGENTS INCREASING WASTE OF TISSUE (DESTRUCTIVE METAMORPHOSIS).

To this class belongs, among others, the group of *alteratives*—remedies the mode of action of which is not made out. Their important function is, however, to modify morbid processes and assist in the removal of abnormal deposits. Many of the compounds of *potassium*, *sodium*, *lithium*, *ammonium*, *barium*, and *calcium* are included in the group. They are alike in many of their physiological effects. In large and long-continued

doses they are waste-producers, stimulating retrograde metamorphosis, and acting as protoplasmic poisons, depressing the action of the heart, and producing muscular paralysis. Their local and special systemic effects will be separately considered.

Potassium.—The principal potassium compounds are—

Potassa, potassium hydroxide, KHO, caustic potash.
Liquor potassæ: dose, ♏v–ʒss.
Potassii acetas, $KC_2H_3O_2$: dose, gr. x–ʒss.
Potassii carbonas, K_2CO_3: dose, gr. ij–x.
Potassii bicarbonas, $KHCO_3$: dose, gr. v–x.
Potassii bitartras, $KHC_4H_4O_6$, cream of tartar; *Potassii et sodii tartras*, $KNaC_4H_4O_6$, Rochelle salt: dose of each, gr. x–℥ss.
Potassii citras, $K_3C_6H_5O_7.H_2O$: dose, gr. v–ʒss.
Potassii chloras, $KClO_3$: dose, gr. v–xv.
Potassii nitras, KNO_3: dose, gr. ij–x.
The bichromate, bromide, and permanganate are elsewhere described.

Physiological Action and Therapeutics.—The above-enumerated salts of potassium are in general antacids, either directly or, in the case of the acetate, tartrate, and citrate, by reduction in the blood into carbonates. They render the urine less acid and more dilute. The nitrate is an active diuretic. The chlorate has been much extolled as an oxidizing agent when internally administered, but is destitute of this property in the animal system, and is a dangerous irritant in large doses. The potassium salts are used largely as diuretics and antacids, especially in the treatment of diseases due or supposed to be due to deficient oxidation of the blood-products or to deficient excretion. Alkaline agents check alkaline secretion and promote acid secretion, and in small doses will favor the outward osmosis of the acid constituents of the gastric juice, and thus improve digestion when that fluid is secreted in insufficient quantities. If the doses given are too large, these acids will be neutralized in the stomach, and the remedy thus cease to benefit. They should be given just before meal-time.

Caustic potash is the most powerful of the alkaline escharotics, and rapidly destroys animal tissue by combining with the water it contains, dissolving its albumen, and saponifying its fatty constituents. Internally administered, it is, unless largely diluted, equally destructive, and is a violent gastro-intestinal irritant. Caustic potash is chiefly employed as a caustic application to fungous growths, to nævi, chancres in the first stage, ingrown nail, etc. Abscesses are sometimes opened with it when the use of the knife is hazardous. The application is a very painful one, and great care is requisite to limit its action to the diseased tissue, as the caustic absorbs water and flows over adjacent parts. Its painful effects can be much mitigated by combining it with lime, as in the official *potassa cum calce* (Vienna paste). This is much the better form to employ in the mouth, where it is sometimes applied in the treatment of cancrum oris and fungous growths of the gum. In combination with carbolic acid, potassa makes an effective application to sensitive dentine. The liquor potassa is used for internal administration when much diluted, and also as a mild caustic.

Potassium acetate, citate, and tartrate have laxative and diuretic power, and are employed to render alkaline the blood and the urine.

The carbonate is antacid, but is so irritant as to be seldom administered internally, the bicarbonate being much less objectionable.

In dental practice the bicarbonate makes a very serviceable and effective mouth-wash to correct acidity of the oral secretions and thus prevent dental decay. Its antacid properties are also useful to neutralize the effects of the mineral acids when taken internally. The use of the tartrate of sodium and potassium as a cathartic is alluded to in connection with that group of agents. As already stated, the power of potassium chlorate to destroy by an oxidizing process the germs of disease in the blood is now no longer relied upon, owing to the fact that it is excreted in an unchanged form. Locally, however, it is a valuable remedy in diseases of the mouth, as aphthæ, stomatitis, ulceration, gangrenous and mercurial, and in inflammation of the gums: it is also a good application for excoriated surfaces, such as occur from wearing badly-fitting artificial dentures. For these purposes from five to ten grains to the ounce of water should be employed.

Potassium nitrate has active diuretic and diaphoretic properties, and was formerly much used as a refrigerant in fevers and in inflammatory affections, especially acute rheumatism; but more reliable remedies have now supplanted it. In dental practice it fulfils no indications which might not be met by other agents.

Sodium.—The principal sodium compounds are—

Soda, sodium hydroxide, NaHO, caustic soda.
Liquor sodæ: dose, ♏v–ʒss, largely diluted with water.
Sodii acetas, $NaC_2H_3O_2.3H_2O$: dose, grs. xx–ʒj.
Sodii carbonas, $Na_2CO_3.10H_2O$: dose, grs. v–xxx.
Sodii bicarbonas, acid sodium carbonate, $NaHCO_3$: dose, grs. x–ʒj.

The sodium compounds are both in chemical structure, physiological effects, and therapeutic uses almost precisely analogous to the potassium compounds, and hence extended mention of their properties and powers is not required. As a series of compounds they are much milder in their action, and are therefore frequently preferred to the potassium salts. This remark applies to the action of caustic soda, from which for caustic purposes a paste corresponding to the *potassa cum calce* is made. (See p. 533 of this volume.)

Sodium bicarbonate makes an excellent mouth-wash to meet the same indications as the corresponding potassium compound. It seems to have some analgesic power, and will sometimes relieve pain in an exposed pulp, for which use it is best applied in the form of a powder; made into a paste with a small amount of water, it will, if immediately applied, relieve the pain of a superficial burn.

Dr. E. C. Kirk kindly contributes the following: "I find sodium carbonate to be a local sedative and obtundent in the treatment of sensitive dentine, not successful in every case, but having a marked effect in allaying hyperæsthesia in very many instances. It is best applied in the form of a thick paste to a perfectly dry cavity. The application causes momentary pain, which is followed by its rapid cessation, and in most instances by a decided anæsthesia of the dentine. As pain returns during the operation of excavation, the application must be renewed.

"In pulpitis from recent exposure an application of sodium carbonate

affords almost instant relief, and if the application be well sealed in with gutta-percha or the preparation known as 'temporary stopping,' death and disintegration of the pulp-tissue ordinarily result without any pain whatever. Its devitalizing action upon the pulp is, however, uncertain, but it affords a reliable and extremely efficacious remedy for pulpitis, and in such cases is an excellent preliminary treatment to the arsenical application.

"Sodium carbonate is of great value in the treatment of devitalized teeth containing semi-putrescent pulps and food-débris. I regard it as a chemical disinfectant and antiseptic in such cases, as it seems to act by saponifying and rendering soluble the contents of the pulp-chamber and canals, so that they may be readily emptied of their putrescent contents by a stream of hot water thrown in by a syringe."

Lithium.—The principal salts of lithium are—

Lithii carbonas, L_2CO_3, very sparingly soluble in water (1:130): dose, gr. ij–xv.
Lithii citras, $L_3C_6H_5O_7$, soluble in 25 parts of water: dose, grs. v–xxx.

Physiological Action and Therapeutics.—The above preparations of lithium, when internally administered, produce effects analogous to those of the potassium and sodium compounds. They have a higher degree of alkalinity, and hence are more efficient as antacid agents. The lithium salts are chiefly employed in the treatment of gout in order to neutralize the excess of uric acid in the blood, with which acid they unite, forming the lithium urate, which, being a soluble salt, is readily eliminated by the kidneys, and is not so likely to form deposits in the joints as are the less soluble sodium or potassium urates, which are formed when salts of those metals are administered. Lithium compounds are also given to prevent the deposit of uric-acid calculi in the kidneys or bladder, and are believed to aid in dissolving them when already formed. Brunton recommends that it be applied locally to parts affected by gouty inflammation, in order to aid in the solution and absorption of sodium urate in the tissues, and also that it be applied to stiffened joints containing chalk-stones, the parts being kept constantly wet with a solution of the lithium carbonate, five grains to the ounce.

In dental practice the lithium treatment is the most effective means known of counteracting the effects of the gouty diathesis upon the teeth and their investments. In gouty inflammation of the peridental membrane the remedy should be employed both constitutionally and locally. By the local use of the carbonate in solution not only may deposits of the urates in the affected tissues be removed, but that wearing away of the teeth so common in the gouty diathesis, and which is thought to be due to an excess of uric acid in the saliva (see p. 388 of this volume), would in a great degree be arrested. For internal administration the lithium carbonate is usually dissolved in carbonic acid water. The citrate can be administered in ordinary aqueous solution.

Calcium.—The principal calcium compounds are—

Calx, calcium oxide, CaO, lime.
Liquor calcis (lime-water), containing the lime in the form of calcium hydroxide, $Ca(HO)_2$: dose, f℥ss–ij.
Syrupis calcis, a syrup holding 5 per cent. of lime in solution: dose, f℥ss–ij.

Calx chlorata. (See *Chlorine.*)
Calcii chloridum, $CaCl_2$: dose, gr. x–xx, in solution.
Linimentum calcis (Carron oil).
Calcii carbonas præcipitatus, precipitated chalk, $CaCO_3$: dose, gr. v–xx.
Creta præparata, prepared chalk: dose, gr. v–xx.
Mistura cretæ, chalk mixture (chalk suspended in cinnamon-water): dose, f℥ss.

Physiological Action and Therapeutics.—Lime in the solid state has long been known as a caustic for unhealthy ulcers and for the removal of abnormal growths and superfluous hairs. Internally it acts as a dangerous irritant.

For internal administration lime-water is generally employed: it holds in suspension only 0.15 per cent. of the calcium hydroxide, but is a mild and excellent antacid preparation, which, like the other alkalies in small doses, favors the gastric secretion, and is especially serviceable in the indigestion of young children, as, when added to milk, it much increases its digestibility and at the same time allays gastric irritability, so that it may be retained when milk alone would be ejected. It is often administered in this form with a view to supplying lime salts to the tissues. Lime-water has some slight astringent power, and this, together with its antacid properties, causes its administration in slight cases of diarrhœa in children. Lime liniment, or Carron oil (in allusion to its use by the iron-workers of Carron), is a mixture of lime-water and either linseed oil or olive oil in about equal proportions. It is a favorite application to burns. Syrup of lime may be used instead of lime-water when great dilution is not requisite. It is given as an antidote to poisoning by carbolic and oxalic acids. In medicinal doses calcium chloride is used in the treatment of chronic glandular enlargement and skin diseases of the strumous type, especially lupus. It is also given to remove tubercular deposits in phthisis.

Precipitated chalk is obtained by a reaction between calcium chloride and sodium carbonate, and prepared chalk is formed by subjecting the crude chalk to a process of elutriation. This consists in stirring the native calcium carbonate in water until it is held in suspension, and then allowing the coarser particles to settle, when the remainder is poured off into another vessel and allowed to subside. These forms of chalk are much employed internally for their antacid properties, chiefly in diarrhœic affections with acidity of the intestinal secretions. Chalk mixture is a favorite method of administration in this class of cases. It is generally given in combination with laudanum; often vegetable astringents, such as catechu and kino, are added.

The chief interest which attaches to preparations of chalk in dental practice is their employment as dentifrices, for which the chemical as well as physical properties of the finer forms admirably adapt them. They will be further alluded to in connection with Dentifrices.

Ammonium.—Ammonia, NH_3, often called "ammonia gas," more properly *amine*, is a colorless gas highly soluble in water. The solution is supposed to contain a compound of amine and water having the formula $NH_4HO(NH_3 + H_2O)$. From the strong resemblance of the solution to solution of potassa and soda, and from the fact that the molecule NH_4 is capable of forming a series of compounds with acid

radicles closely resembling the same compounds of potassium and sodium, NH_4 is usually called *ammonium*. NH_4HO (analogous to KHO) is ammonium hydroxide. NH_4Cl (analogous to KCl and NaCl) is ammonium chloride.

Ammonium compounds are all volatile. The hydroxide and carbonate are diffusible stimulants.

PREPARATIONS:

Aqua ammoniæ fortior, stronger water of ammonia, made by passing sufficient ammonia gas into water to make its specific gravity 0.900 at 59° F.

Aqua ammoniæ, ammonia-water. This is the stronger aqua ammonia diluted with 2 parts of water, specific gravity 0.959 at 590° F.: dose, ♏v–ʒss, much diluted.

Spiritus ammoniæ, a 10 per cent. solution of ammonia gas in alcohol: dose, ♏x–fʒj, greatly diluted.

Ammonii carbonas, $NH_4HCO_3NH_4NH_2CO_2$: dose, gr. ij–x.

Spiritus ammoniæ aromaticus is an alcoholic solution of ammonium carbonate and aqua ammonia, flavored with oils of lemon, lavender, and nutmeg: dose, fʒss–ij.

Ammonii chloridum (muriate of ammonia, sal ammoniac), NH_4Cl: dose, gr. j–xx.

Linimentum ammoniæ.

Liquor ammonii acetatis (spirit of Mindererus): dose, fʒj–f℥ss.

PHYSIOLOGICAL ACTION.—Ammonia gas is highly alkaline, and is intensely irritant to all mucous surfaces, and also to cutaneous surfaces when vaporization is prevented. When inhaled it instantly causes spasmodic action of the glottis and an intensely suffocative feeling; inflammation is sometimes the result of its prolonged or too violent action. Both the conjunctiva and the nasal mucous membrane are equally susceptible to its influence, profuse lachrymation and a free secretion of nasal mucus being the result of its local contact with those surfaces. By this irritant effect the nasal branches of the fifth nerve are stimulated, this being followed by a reflex excitation of the vaso-motor centre, with a consequent increase of arterial pressure and a corresponding antagonism to the condition of shock or syncope. When a strong ammonia solution is swallowed it causes violent inflammation of the mucous membrane of the mouth, fauces, œsophagus, and stomach. The glottis may become œdematous, and death from suffocation follow. In medicinal doses ammonia is a stimulant both to the respiratory and circulatory centres, but in poisonous doses it exercises a directly depressing influence on the brain. Ammonium salts stimulate the glycogenic function of the liver and increase the secretion of the bronchial and intestinal mucous glands, and also of the sudoriferous glands and the kidneys. In the blood ammonia is thought to be largely converted into urea.

THERAPEUTICS.—Aqua ammonia is often administered by inhalation as a stimulant in fainting or severe shock; when so used care must be observed not to make the application too prolonged or severe, as inflammation may result. Ammonia-water and ammonia liniments are useful counter-irritants, and the former may be employed as a vesicant. It is also a serviceable lotion for the stings of poisonous insects. By the injection of a few drops into the wound made by venomous reptiles the poison can sometimes be neutralized. Spirit of ammonia has similar uses, and is not so powerfully irritative as the ammonia-water. They are both used internally as antacids and (instead of alcohol) as stimulants in syncope or great physical depression and weakness, and as enemata in narcosis. Ammonium

carbonate is also much employed to meet these indications, a favorite preparation being the aromatic spirits of ammonia. Ammonium chloride is much used in hepatic disorders attended by jaundice and where the intestinal secretions are deficient and there is much constipation. It is an efficient agent also in bronchial affections, especially of the aged, when the mucous secretions are scanty and difficult of expulsion, and has considerable efficacy in neuralgia. Spirit of Mindererus is much used as a diaphoretic in the early stage of catarrhal and rheumatic affections, and is also frequently administered in eruptive fevers when the eruption is slow in making its appearance. As a stimulant it is often employed in typhoid and typhus fevers.

In dental practice ammonia and ammonium carbonate are used as stimulants in the dangerous narcosis following the administration of anæsthetics. When taken internally, the chloride often has a good degree of efficacy in facial neuralgia, and ammonium acetate may be administered as a diaphoretic and refrigerant in inflammations of the peridental membrane, for which use it may be associated with either aconite or opium, or both.

Acidum Aceticum (ACETIC ACID).—The official acetic acid contains 36 per cent. of the true acid, $HC_2H_3O_2$, and 64 per cent. of water. It is a clear, colorless liquid strongly acid and entirely volatile, miscible in all proportions with water; specific gravity, 1.048.

PREPARATIONS:

Acidum aceticum glaciale, glacial acetic acid, $HC_2H_3O_2$. It is a strongly escharotic liquid which freezes at 59° F.

Acidum aceticum dilutum, dilute acetic acid, contains 17 parts of the official acetic acid and 83 parts of distilled water, has a specific gravity of 1.008, and contains 6 per cent. pure acid.

Acetum, vinegar, is impure, highly dilute acetic acid.

PHYSIOLOGICAL ACTION.—Concentrated acetic acid is a corrosive irritant poison, producing the usual symptoms of gastro-enteric inflammation. Dilution diminishes its activity, and in vinegar we have it so far diluted as to be an agreeable refrigerant condiment. Long-continued use produces emaciation.

THERAPEUTICS.—The concentrated (glacial) acid has been used as a caustic in cancer by injection into the growth, but the results have not been satisfactory. It has also been employed as an escharotic for warts, corns, and condylomata, and as an antiparasitic in pityriasis and other skin affections. The dilute acid can be advantageously applied in the form of a sponge-bath to reduce surface temperature in fevers. Internally it has been taken in large amounts to reduce obesity.

Acetic acid has some antiscorbutic power, and may be employed in the treatment of scurvy, both as a local application to the affected gums and by internal administration. It is a good local remedy in cancrum oris and fungous growths of the gum and dental pulp. For these uses the stronger acid is required, and it is best applied by means of a pointed pine stick, healthy surfaces being carefully protected from contact.

Tartaric Acid ($H_2C_4H_4O_6$) and **Citric Acid** ($H_3C_6H_5O_7$) resemble acetic acid in effects and uses.

Sulphur.—Three forms of the element, differing only in physical condition, are official.

PREPARATIONS:

Sulphur sublimatum: dose, gr. x–xx.
Sulphur lotum: dose, gr. v–xxx.
Sulphur præcipitatum: dose, gr. x–xxx.
Unguentum sulphuris.
Unguentum sulphuris alkalinum.

Sulphur is a laxative, alterative, and germicide. The first effect is best obtained with the element; the second action belongs more especially to the sulphides; and the germicide action is strikingly seen in the sulphites.

Sulphides.—Hydrogen sulphide, H_2S, sulphuretted hydrogen. This is a gaseous compound, one of the products of decomposition of albuminous matters, and also of the decomposition of metallic sulphides by acids. Two impure sulphides are official. *Potassa sulphurata, hepar sulphuris,* liver of sulphur, sulphurated potash, is a mixture of potassium sulphide, hyposulphate, and sulphate. *Calx sulphurata,* sulphurated lime, is a mixture of calcium sulphide and sulphite.

Calcium sulphide, CaS, and hydrogen sulphide, H_2S, are unofficial, but frequently used, as being more exact in chemical composition.

Sulphuretted Waters.—In various parts of the world springs occur containing sulphides, but varying considerably in the proportion and character of the constituents. In many cases they contain the gas, hydrogen sulphide, in solution; others contain only metallic sulphides, as calcium or sodium sulphide, which by the action of carbonic acid is transformed into hydrogen sulphide, substantially according to the following reaction:

$$Na_2S + H_2CO_3 = Na_2CO_3 + H_2S.$$

Many of these waters are the result of the action of organic matters upon sulphates; thus, calcium sulphate, $CaSO_4$, is reduced to calcium sulphide, CaS, the oxygen going to the organic matter; this sulphide will then decompose according to the reaction just given. The action of carbonic acid on the sulphides is taken advantage of in the recently-introduced method of treating phthisis by gaseous enemata, carbonic acid being slowly passed through a solution of a sulphide, and then injected into the bowel.

The following are some of the best-known sulphuretted waters: Blue Lick, Kentucky; Sharon, New York; Greenbrier, White Sulphur, Virginia; Harrogate, England; Eaux Bonnes, Pyrenees; Aix-la-Chapelle; Challes, Savoy; Neundorf, Prussia; Schintznach, Switzerland.

PHYSIOLOGICAL ACTIONS.—Sulphur and the sulphides in small doses are laxative and slightly stimulant; in large doses they act as a gastro-intestinal irritants. Hydrogen sulphide has a direct narcotic effect when inhaled, and all the sulphides probably diminish the number of the blood-corpuscles and increase the waste of tissue. They are destructive to both animal and vegetable life, and hence act as germicides and antiparasitics. Long-continued use causes emaciation, cardiac debility, and general prostration. It appears from the experiments above mentioned that hydrogen sulphide may be introduced into the intestines in quantities which it

would be unsafe to inhale, and it will then be slowly excreted by the lungs.

THERAPEUTICS.—Sulphur and the sulphides are used in affections attended by or dependent on diminished action of the glandular apparatus—torpid liver, obesity, hemorrhoids, and a liability to boils and small abscesses, rheumatism, and neuralgias. The disinfecting power is utilized externally in the treatment of skin diseases, especially scabies. Sulphur-water baths are used in the treatment of eczema and psoriasis.

The rectal injection of carbonic acid gas charged with a small percentage of hydrogen sulphide in the treatment of pulmonary phthisis, asthma, and other affections of the respiratory organs has already been referred to.

Iodum (IODINE) is a bluish-black crystalline solid, soluble in alcohol, ether, and glycerin, but only sparingly soluble in water. It is very volatile: dose, gr. ss–ij.

PREPARATIONS:

Liquor iodi compositus, Lugol's solution: dose, ♏j–x.
Tinctura iodi: dose, ♏j–v.
Unguentum iodi.
Potassii iodidum, KI: dose, gr. v–ʒj.
Sodii iodidum, NaI: dose, gr. ij–xx.
Ammonii iodidum, NH_4I: dose, gr. ij–x.
Unguentum potassii iodidi.
Iodoformum, iodoform, CHI_3: dose, gr. j–v.

PHYSIOLOGICAL ACTION.—Applied to either skin or mucous membrane iodine produces a transient yellow stain, but by repeated applications the epithelium is destroyed, and even vesication may be produced. Like chlorine and bromine, although more feebly, iodine is an antiseptic, a deodorant, and a germicide. These properties belong to the vapor. The deodorant quality is due to the affinity for hydrogen contained in the gases, hydrogen sulphide and hydrogen phosphide, generally produced in putrefaction (*e. g.* $H_2S + I = 2HI + S$); but the effect may also be induced through the affinity of iodine for the hydrogen of water, by which oxygen is set free, $H_2O + I_2 = 2HI + O$. This nascent oxygen is an active oxidizing agent. The vapor of iodine is very irritating to the mucous membrane of the air-passages. Internally, in small doses, iodine stimulates the circulation of the stomach, and is quickly absorbed and diffused through the system. In full doses it may act as an irritant poison. Continued administration of small doses gradually develops a condition known as *iodism*, among the symptoms of which are headache, loss of strength, waste of tissue, catarrhal conditions of the conjunctival, nasal, and bronchial mucous membrane, sore throat, disordered taste, slight rise in temperature, and an eruption of acne or eczema. These symptoms begin to subside as soon as the remedy is discontinued, or even while still continuing, as a tolerance is established. In medicinal doses there are no clear indications of direct effect on the nervous system. Long-continued use diminishes sexual power.

THERAPEUTICS.—Tincture of iodine is much used as a local application in glandular swellings, boils, and other superficial local inflammations before the formation of pus. It is used as a counter-irritant for throat and chest inflammation, and also to promote absorption of serous

effusions, and may be injected into the structure (parenchymatous injection) of hypertrophied tonsils and glandular and cystic growths, absorption being thereby actively stimulated. Applied to the surface of serous membranes, it destroys their secretory power, and in this way is used for the treatment of hydrothorax and hydrocele.

The systemic effect of iodine is generally obtained by the administration of the iodide or of the compound solution of iodine. These preparations are contraindicated in cases of inflammation of the digestive tract. The principal use of the iodides is in the treatment of certain special morbid states of the system, notably syphilis and scrofula, in the former of which they are particularly efficacious, the value of the iodides being especially manifested in the so-called tertiary stage of the disease. The iodides are also employed in nervous disorders, paralyses, neuralgias, and epileptiform seizures. They are given in large doses (gr. xl) of potassium iodide three times daily until symptoms of iodism are developed. Good effects are reported from the use of potassium iodide in aneurism. In acute catarrh and spasmodic asthma, and in chronic affections of the bronchi and lungs attended by profuse secretion, the iodides are used internally; and benefit is sometimes derived from the inhalation of air impregnated with small quantities of the vapor of iodine. The enlargements of the liver and spleen caused by malarial impression are removed by moderate doses of the iodides. Tincture of iodine with carbolic acid forms a combination now much in favor with certain practitioners in the treatment of typhoid fever.

The internal administration of the iodides is much resorted to for the elimination of lead, copper, and mercury in cases of chronic poisoning by those metals. The action is supposed to be due not only to the increased activity of the secretion and excretion, but to a special solvent power which potassium iodide has over the other iodides. Mercuric iodide, HgI_2, while wholly insoluble in water, is readily soluble in solution of potassium iodide.

In dental practice iodine is extensively employed as a counter-irritant in the treatment of inflammations of the peridental membrane and of the gum-tissue. It is also used as a dressing to putrescent pulps and to pulp-canals in a septic condition. Its efficiency as an antiseptic disinfectant and deodorizer has already been alluded to. Its affinity for hydrogen compounds is of special service in pulp-canals, as such gases are decomposed, hydriodic acid gas being formed, this being readily taken up into solution by the fluids present in the teeth, and pressure of gases through the apical foramen being thus in a great measure obviated. Except to roots destitute of crowns, iodine should not be very frequently applied, as a permanent discoloration of the dentine is quite likely to result through absorption of the solution into the tubuli. As a stimulant and disinfectant injection in chronic alveolar abscess iodine has a high degree of efficacy. For this use, as well as for putrescent pulps, an alcoholic solution much stronger than the official tincture should be employed. A good formula for dental purposes is—

℞. Iodi, ʒij;
Alcoholis, f℥ij. M.

This forms nearly a saturated solution. This stronger application will also be found more efficient as a counter-irritant to the gum-tissue than is the weaker tincture.

As an injection into alveolar abscesses and fistulæ, cysts, ranula, etc. it may generally be advantageously combined with carbolic acid, after the following formula:

℞. Iodi,
Acidi carbolici (crystals), *āā.* ℥j;
Alcoholis, f℥ij. M.

This combination is often of great service in pyorrhœa alveolaris, and also as an application to fungous growths of the dental pulp or to hypertrophy of the gum, such growths, under the influence of these agents, being speedily dissipated through arrest of cell-proliferation and by a breaking down of their albuminoid constituents, with which both iodine and carbolic acid promptly unite. Ranula can often be permanently cured by applying to the entire inner surface of the sac the stronger tincture above recommended. The application is much more likely to be successful if a portion of the wall of the sac is cut away. This establishes a drain not readily closed, and permits a much more thorough application of the iodine.

Hydrargyrum (MERCURY) is well known as the only common metal liquid at ordinary temperatures. In the pure state it is not easily dissolved, and it has been administered in very large doses for the relief of obstruction of the bowels without any physiological effect. By strong trituration with some excipient it is gradually reduced to a fine powder and partially oxidized. In this state it is easily absorbed. Mercury forms two well-marked series of salts, the chemical and physiological properties of which are decidedly different. In one series, called the *mercurous*, the mercury has its lower combining capacity; in the other series, called the *mercuric*, it has its higher capacity. Many mercurous salts are written with doubled formulæ: Hg_2Cl_2, mercurous chloride; Hg_2I_2, mercurous oxide. The mercuric salts are, as a rule, much more active and poisonous than the mercurous salts.

PREPARATIONS:

Hydrargyrum cum creta: dose, gr. ss–x.
Massa hydrargyri: dose, gr. ss–xx.
Unguentum hydrargyri.
Hydrargyri chloridum mite, mercurous chloride, calomel, Hg_2Cl_2: dose, gr. $\frac{1}{5}$–x.
Hydrargyri chloridum corrosivum, mercuric chloride, corrosive sublimate, $HgCl_2$: dose, gr. $\frac{1}{80}$–$\frac{1}{15}$.
Hydrargyri iodidum viride, mercurous iodide, Hg_2I_2: dose, $\frac{1}{10}$–$\frac{1}{3}$.
Hydrargyri iodidum rubrum, mercuric iodide, HgI_2: dose, $\frac{1}{50}$–$\frac{1}{20}$.
Liquor hydrargyri nitratis, acid nitrate of mercury, $Hg(NO_3)_2$, with an excess of nitric acid.
Unguentum hydrargyri nitratis, citrine ointment.

PHYSIOLOGICAL EFFECTS.—The effects of mercury are largely dependent upon the preparations used and the manner of administration. The mercuric compounds, as above noted, are generally the more active: the difference between the two series is most strikingly shown in the chlorides, one of which, $HgCl_2$, mercuric chloride, is a

powerful corrosive irritant poison in doses of one or two grains or even less, while the other, calomel, may be given in ten-grain doses without irritant effect.

In small doses mercurial salts stimulate the lymphatic system, increase the number of red corpuscles, and act, therefore, as a blood-tonic. If the administration be long continued, these actions are reversed: the blood degenerates, the nutritive processes are interfered with, and a train of symptoms denoting marked anæmia and retrograde metamorphosis results. There is loss of flesh, ulceration of skin, fetid breath, diarrhœa, increase of the salivary secretion, soreness and loosening of the teeth, spongy gums with a blue line along the upper margin, and swelling of the salivary glands. There are also slight fever and muscular pains. To these symptoms, which mark a chronic poisoning by accumulation of the metal in the glandular structures, the term *ptyalism* or *salivation* is applied. This condition may arise from constant exposure to the fumes of mercury or its compounds, and it is sometimes, as in the treatment of syphilis, intentionally produced for the purpose of causing a deep alterative action. Blue pill, calomel, and mercury with chalk are the suitable preparations for this purpose. In the condition of ptyalism it is obvious that the waste of tissue is greatly increased, and as the plasticity of the blood-fibres is much diminished, the liability to the formation of morbid (hyperplastic) deposits is also lessened.

Acute poisoning by mercurials more frequently occurs from corrosive sublimate than from the other preparations of mercury; sometimes, however, it is caused by the acid nitrate. The symptoms are those of violent corrosive irritant action on the stomach and bowels. The discharges are bloody. This fact and the quick arrest of the symptoms constitute distinctions from arsenical poisoning. The treatment is the free use of albuminous matter—eggs, blood, milk, and flour. Eggs are by far the best: one egg will form an insoluble mass with four grains of corrosive sublimate. The coagulum must be removed from the stomach, as it may be digested and the symptoms recur.

THERAPEUTICS.—Mercury has been long used as a therapeutic agent, and was at one time very extensively employed. The purgative action of some of its preparations is largely utilized in catarrhal conditions of the intestinal mucous membrane and in the disorders grouped under the popular but vague term "biliousness." Calomel in doses of half a grain to a grain, repeated once or twice, is an effectual purgative for children; for adults five or ten grains are required. Acute glandular affections of the throat are often relieved by minute doses (gr. $\frac{1}{20}$) of calomel frequently repeated. This treatment is not suitable for scrofulous inflammations of these organs.

Such of the mercurials—*e. g.* calomel and blue pill—as permit of use in moderate doses possess a directly stimulant influence on the glands and act as cholagogue cathartics. This action on the liver is regarded as rather reflex than direct; that is, it stimulates the upper intestine, and irritation of the duodenum is conveyed by continuity of mucous surface to the bile-ducts.

The powerful mercurials, corrosive sublimate, red iodide, acid nitrate, are energetic germicides. The first named is regarded as one of the

most efficient antiseptics and disinfectants known. It coagulates the protoplasmic cell-contents of all living organisms.

Mercurials are no longer in favor for the treatment of hepatic affections or for acute inflammation of serous membranes, except in those cases dependent on a syphilitic origin.

Calomel in large doses has been strongly recommenced in the early stage of typhoid fever, being by some regarded as almost a specific. It has also been advised in Asiatic cholera.

The principal use of mercury is in the treatment of syphilis, for which it is regarded as a specific. It is to be used from the very beginning of the lesion; that is, from the appearance of the hard chancre or other sign of constitutional involvement. Syphilographers now very generally agree that the chancroid is not an infecting sore and that it does not call for constitutional treatment. The old practice of carrying the mercurial impression to ptyalism is now out of favor, but it is generally conceded that the best effects are obtained by continuing the action for a considerable time, interrupting it whenever tenderness of the teeth is observed.

Mercury may be introduced by fumigation or by hypodermic injection, as well as by internal administration. The hypodermic method is highly indorsed. Corrosive sublimate in $\frac{1}{12}$-grain doses, once daily, is preferred.

The green and red iodides of mercury are chiefly employed in the treatment of constitutional syphilis, the preparation combining the alterative influence of both mercury and iodine. The red iodide, even in small doses, is a dangerous irritant poison, and it must be given with great care. Many practitioners prepare it extemporaneously by a reaction between mercuric chloride and a solution of potassium iodide, in which it is freely soluble, although insoluble in water.

In dental practice mercurials are chiefly employed as caustics, cathartics, and antiseptics. Their cathartic properties are referred to in connection with those agents, and their antiseptic power will be considered under "Topical Remedies."

Acid nitrate of mercury is never given internally, but locally applied it is a powerful caustic, rapidly destroying the tissue to which it is applied, and is by many regarded as one of the most active and remedial applications to indolent and indurated ulcers, especially those which are syphilitic in character. In ulcerative stomatitis, and also in destructive forms of cancrum oris, it may often be applied with advantage. Some care must be observed in its use, as it is easily absorbed and its incautious employment has frequently resulted in serious mercurial poisoning. The ointment of nitrate of mercury is chiefly used in skin disease. It is a powerful stimulant and caustic, and generally it is necessary to dilute it with lard. Constitutional symptoms are to be guarded against in the use of this preparation also.

Treatment of Ptyalism and Chronic Poisoning.—When dependent on the administration of mercurials or known sources of mercurial impression, the removal of the cause is of course the first requisite. Careful inquiry should be made into the surroundings in cases in which the source of the disease is not apparent. Chronic mercurial poisoning

has occasionally arisen from constant exposure to vapors of the mercury used in sealing joints for gas-fixtures, etc., and the extended use of mercuric chloride and iodide as antiseptics is also a source of danger.

Dilute sulphuric acid associated with bitter tonics is used internally in the treatment of ptyalism. Belladonna in small doses, about five drops of the tincture three or four times daily, is recommended by Bartholow. Locally, astringent washes, such as tannic acid, borax, dilute alcohol, are employed, and a strong solution of potassium chlorate (ʒj to f℥vj of water) is also used. Potassium iodide is occasionally employed internally, but sometimes increases the trouble.

Cuprum (Copper).—Metallic copper, unless in very fine division, is inert.

Preparations:

Cupri sulphas, $CuSO_4 + 5H_2O$, blue vitriol: dose, gr. $\frac{1}{16}$, for long-continued use. As an emetic, gr. ij–xij.

Cupri acetas, $Cu(C_2H_3O_2)_2H_2O$, is used locally only.

Physiological Effects.—Copper salts are not as poisonous as was formerly supposed. Several instances are now recorded in which small amounts have been regularly ingested without apparent injury, and the metal is found in minute amount in the brain and liver. Nevertheless, in small quantities copper can produce the usual symptoms of chronic metallic poisoning, gastro-enteric derangement, anæmia, colic with diarrhœa, partial paralysis, and sometimes discoloration of the gums. Chronic and even acute poisoning occasionally occurs from the use of articles cooked in copper vessels or colored by copper salts. Acute poisoning by copper is to be treated by the use of albuminous matter, demulcents, and non-irritating emetics if the emesis is not already sufficient. Potassium ferrocyanide in doses of a few grains is a chemical antidote. In the solid form or in strong solution copper sulphate is a mild caustic and is destructive to parasitic growths. Internally, in small doses, copper is an astringent tonic.

Therapeutics.—Copper sulphate is employed locally for superficial inflammation and ulceration of the mucous membrane, especially in granular conjunctivitis and aphthous ulcers. An ointment of the acetate is employed in parasitic skin affections (copper oleate, which is not official, is preferred by some). In narcotic and phosphorus poisoning copper sulphate, in doses of about twelve grains repeated once or twice, is a prompt and efficient emetic. Internally, copper sulphate in small dose (gr. $\frac{1}{12}$) is considered the best astringent in gastro-intestinal affections, particularly in chronic dysentery and acute diarrhœa; also in the diarrhœa of phthisis and in cholera infantum. Copper acetate has been suggested for internal use in pneumonia, and the use of copper has also been recommended in facial neuralgia.

In dental practice copper sulphate is chiefly employed in the treatment of fungous growths of the gum and pulp, aphthous ulcerations, ulcerative stomatitis, cancrum oris, etc. In these disorders it is applied in various strengths, from five grains to the ounce of water to the powdered crystals without dilution, as may be called for by the requirements of the case: the more obdurate and malignant types of ulceration require

the stronger applications. Copper sulphate is often particularly efficacious, succeeding when other caustics fail.

Argentum (SILVER).—Metallic silver has no therapeutic effect.

PREPARATIONS:

Argenti oxidum, Ag_2O: dose, gr. ss–ij.

Argenti nitras, $AgNO_3$, lunar caustic: dose, gr. $\frac{1}{6}$–$\frac{1}{2}$.

Argenti nitras fusus and *argenti nitras dilutus* are forms of the same body melted and cast in sticks, the latter being mixed with an equal quantity of potassium nitrate.

Argenti iodidum, AgI: dose, gr. $\frac{1}{4}$–j.

Argenti cyanidum, not used internally.

Silver salts are so easily decomposed by organic bodies and various salts that they should be given alone.

PHYSIOLOGICAL ACTION.—The soluble salts of silver, such as the nitrate, are corrosive irritants and escharotics, but the effect is superficial. On the unbroken skin they produce a black stain, but only the upper layer of cells is affected. Internally, silver affects the composition of the blood, which becomes darker and more fluid; it increases secretion and impairs the functions of the nervous system. Its long-continued use causes an accumulation in the tissues, with symptoms of chronic poisoning—paralysis, fatty degeneration of various viscera, albuminuria, a blue line along the margin of the gum, and a blue discoloration of the skin. The antidote to poisoning by silver salts is sodium chloride (common salt) used freely, which immediately causes the formation of an insoluble silver chloride, and also acts as an emetic.

THERAPEUTICS.—Locally, silver nitrate in sticks or in dilute solution in distilled water is employed as an escharotic, caustic, and astringent application in inflammations of the skin and mucous membranes, and for ulcerations of the mouth and tongue. Silver nitrate must be used with care about the eye, as corneal opacity may result from its chemical action on that tissue. A solution of the nitrate in nitrous ether (gr. x : f℥j) acts more rapidly than the solution in water.

Silver nitrate and oxide were formerly much used in the treatment of epilepsy, but the uncertainty of their action, their liability to produce permanent discoloration of the skin, and also the now general employment of the bromides in this disorder, have led to the almost entire abandonment of the silver preparations. They are, however, highly advantageous in the treatment of gastric catarrh and gastric ulcer, chronic dysentery (especially when attended by ulceration), dyspepsia, and in the diarrhœa of phthisis and of typhoid fever. Silver has also been used with success in chronic spinal troubles. In this class of cases discoloration rarely follows its use, as the doses are not so large, nor is so long a period of treatment requisite, as in epileptiform disorders.

In dental practice silver nitrate is a valuable caustic application to aphthous ulcerations of the milder type, and also as a styptic in alveolar hemorrhage. Solutions of various strengths, from one grain to thirty grains to the ounce of water, are to be employed. As an obtundent of sensitive dentine it has considerable power. For this use the solid fused nitrate is the most convenient form for application. Before use it should be placed in a *porte caustique* or other suitable carrier for

protection of the fingers of the operator. A goose-quill answers a good purpose. The stick of silver nitrate, slightly moistened, is applied directly to the sensitive surface, the tooth being previously dried and protected from moisture. By the application a rapid coagulation of the protoplasmic contents of the tubuli is effected, with a consequent inhibition of their power of transmitting sensation. The permanent blackening of the teeth which is liable to follow the application is a serious objection to the employment of the agent.

Aurum (GOLD).—Metallic gold is entirely inert.

PREPARATION:

Auri et sodii chloridum, $NaCl + AuCl_3$: dose, gr. $\frac{1}{30}$–$\frac{1}{60}$.

The unofficial gold chloride, $AuCl_3$, is also occasionally used.

PHYSIOLOGICAL ACTION AND THERAPEUTICS.—Gold chloride somewhat resembles corrosive sublimate. Locally it is an antiseptic and escharotic. In small doses internally it acts as a tonic to the digestion, and stimulates the nervous system. In large doses it acts as a poison, producing gastro-enteric inflammation and convulsions.

It is employed in the treatment of a variety of chronic affections associated with hyperplastic formations, including syphilis.

In dental practice gold chloride is recommended as an application to sensitive dentine, for which purpose a solution in ether is suitable. The ethereal solution should be kept closed and away from the light. It may be applied on a pledget of cotton.

Plumbum (LEAD).—Metallic lead is probably inert, except in fine powder or when superficially oxidized.

PREPARATIONS:

Plumbi acetas, $Pb(C_2H_3O_2)_2 + 3H_2O$, sugar of lead: dose, gr. $\frac{1}{4}$–iij.

Liquor plumbi subacetatis, Goulard's extract, a compound of lead acetate with lead oxide.

Liquor plumbi subacetatis dilutus, lead-water.

Ceratum plumbi subacetatis, Goulard's cerate.

Plumbi carbonas, $PbCO_3$, white lead, generally contains some $Pb(HO)_2$.

Unguentum plumbi carbonatis.

Plumbi nitras, $Pb(NO_3)_2$.

Plumbi iodidum, PbI_2.

Plumbi oxidum, litharge, PbO, used to prepare *emplastrum plumbi*, lead plaster.

The acetate is the only preparation used internally.

PHYSIOLOGICAL ACTION.—Lead has a very marked and powerful systemic action. In large doses the soluble salts are irritant poisons, producing violent vomiting and purging, by which much of the poison may be expelled. The antidotes are the soluble sulphates, such as Epsom salt and alum, which form insoluble lead sulphate. Sometimes paralysis, coma, and collapse are the result of excessive doses. Fatal results are not common.

The continual ingestion of minute amounts of lead, however, gives rise to a train of symptoms known as *plumbism*. These conditions may arise from the presence of lead in drinking-water or food, from exposure to fine dust of lead compounds, from handling lead, or the use of cosmetics containing lead. The earliest symptoms of chronic lead-poisoning are loss of appetite and strength, constipation, and

anæmia; the joints become painful, and colicky pains, relieved by pressure, also occur. The skin and conjunctiva become jaundiced, and very frequently there is noticed a distinct slate-colored line along the gums. As the disease progresses neuralgia occurs and diminished sensibility and vision. Paralysis of the extensor muscles of the forearm, resulting in "drop-wrist," constitutes a striking symptom. Convulsions and delirium are sometimes seen in advanced cases.

Medicinally employed, lead acetate internally is an astringent and diminishes secretion; locally, the preparations generally are sedative.

Lead forms many insoluble compounds; hence its preparations are incompatible with a large number of substances, especially sulphates, carbonates, chlorides, and vegetable astringents. Opium precipitates lead acetate, but the activity of neither remedy is seriously diminished.

THERAPEUTICS.—Lead acetate is used in gastric ulcer attended with vomiting of blood and in gastric catarrh. It is largely employed as an astringent in diarrhœas of various forms. It is generally used with opium, either in pill or powder. Bartholow advises the following:

Take of Lead acetate, gr. xxiv;
Powd. opium, gr. xij;
Powd. camph. ʒss;
White sugar, q. s.

Make twelve powders, one to be taken every hour or two.

Lead acetate is used in the treatment of hemorrhage or in hæmoptysis, and also to diminish secretion in bronchial troubles. In all cases of its internal use care should be taken not to induce the condition of chronic poisoning. When such a condition is established, the free use of potassium iodide is considered the best treatment.

Locally, the preparations of lead are used for their sedative, protective, and astringent properties in the treatment of burns and in various skin affections. The ointment of the carbonate, or even white-lead paint, is very useful when the burn is not extensive; applied over large surfaces it may cause dangerous symptoms. A solution of lead nitrate in glycerin (gr. x–f℥j) is a useful application for fissured nipples. A mixture of lead-water and laudanum has been long used as an application to inflamed or injured surfaces, but is now not much in favor.

In dentistry, lead acetate is chiefly used in solution for the treatment of inflamed gums; it is especially efficacious for the relief of the pain and inflammation which sometimes follow tooth-extraction, especially when there has been much laceration of the tissue. For this use it may be advantageously combined with tincture of opium. (See OPIUM.)

Zincum (ZINC).—Metallic zinc is inert.

PREPARATIONS:

Zinci oxidum, zinc white, ZnO.
Unguentum zinci oxidi.
Zinci sulphas, white vitriol, $ZnSO_4+7H_2O$: dose, gr. $\frac{1}{4}$–vj.
Zinci acetas, $Zn(C_2H_3O_2)_2+3H_2O$: dose, gr. ss–ij.
Zinci valerianas, $Zn(C_5H_9O_2)_2+H_2O$: dose, gr. $\frac{1}{4}$–j.
Zinci carbonas præcipitatus ($ZnCO_3$).
Ceratum zinci carbonatis.
Zinci chloridum, $ZnCl_2$.
Liquor zinci chloridi.

The above preparations, with the exception of the acetate and sulphate, are intended for external use.

Physiological Action.—In large doses the soluble salts of zinc are active poisons, especially the chloride, which is an escharotic, acting chemically on the tissues. In moderate doses the sulphate is an emetic. In small amounts frequently repeated zinc salts may produce a condition of chronic poisoning, but they are much less liable to produce this effect than lead.

In medicinal doses zinc salts produce effects analogous to but milder than those of lead and copper. Locally, in dilute solution the effects are astringent and sedative.

Internally administered, the preparations are antispasmodic, especially when the spasmodic state is intermittent (clonic).

Therapeutics.—Zinc sulphate is a favorite emetic in narcotic poisoning. In conjunction with other astringents—even with lead acetate, with which, however, it is chemically incompatible—its solution is often used as a sedative astringent in mucous inflammation, such as conjunctivitis, urethritis, and catarrhal affections.

Internally, the zinc salts are used in diarrhœa, dysentery, and gastralgia. Their antispasmodic action is utilized in the treatment of epilepsy, chorea, hysterical troubles, spasmodic asthma, and whooping cough. The escharotic effect of the chloride is frequently utilized for the destruction of malignant growths. The dried sulphate may also be used for unhealthy ulcerations. Solutions of the acetate and ointments of the oxide and carbonate are employed locally in skin affections. Ointment of the oxide is a largely-used dressing for wounds. The finely-powdered oxide is usually an ingredient of face-powders.

In dentistry, zinc chloride in strong solution (20 to 30 per cent.) is used as an application in calcic inflammation (see Vol. I. p. 966), and the crystals, allowed to absorb water until just liquefied, are used to obtund sensitive dentine, by being placed directly in contact with the previously dried surface. The application produces much pain, and must be repeated from time to time as the excavation proceeds. The pain may be reduced by the previous use of chloroform, aconite, or cocaine. It must, however, not be directly applied to the tooth-pulp. Zinc chloride, applied locally, is not absorbed to any great degree, and hence is not likely to produce systemic effects. It may be used as a hæmostatic in wounds of the gum and as an astringent in profuse mucous secretion. For these uses a dilute solution is employed. It is used in treatment of chronic alveolar abscess with recession of the gum. A paste made by mixing zinc oxide with a solution of carbolic acid is recommended by Dr. J. S. King as a capping for exposed pulps. (See Vol. I. p. 897.) Equal parts of carbolic acid and oil of cloves may also be used instead of carbolic acid alone. (See Vol. II. p. 156.)

Zinc iodide, ZnI_2, is not official, but is now used locally as a stimulant and an escharotic, and is thought to be superior to zinc chloride. It is highly recommended as an application for enlargement of the tonsils and in pyorrhœa alveolaris. Dr. A. W. Harlan has suggested the following formula for alveolar application :

Take of Zinc iodide, gr. xv;
Water, f℥j. M.

Dry the gums well and inject a drop or two of this solution into each pus-secreting cavity. In bad cases the strength of the solution may be increased to twenty grains to the ounce.

Antimony.—Metallic antimony is not used in medicine, but a number of its compounds are official.

PREPARATIONS:

Antimonii et potassii tartras, tartar emetic. This salt is not strictly analogous to ordinary metallic salts, since it contains an oxide, SbO, replacing hydrogen. Its formula is $K(SbO)C_4H_4O_6 + H_2O$. It is one of the few antimony compounds which are not decomposed by water; hence it is preferred: dose, $\frac{1}{16}$ to $\frac{1}{4}$ gr. up to gr. j.

Vinum antimonii, wine of antimony, contains 2 grains of tartar emetic to the fluid ounce: dose, ♏v–x. The other preparations are but little used.

PHYSIOLOGICAL ACTION.—Antimonial preparations are markedly depressant, nauseant, emetic, and diaphoretic. In large doses violent gastro-enteric irritation and inflammation, with copious discharges and great prostration, are produced; a cutaneous eruption resembling small-pox is produced by both the external and internal use of tartar emetic. Vegetable astringents are antidotal.

THERAPEUTICS.—Tartar emetic in small doses (gr. $\frac{1}{60}$ to $\frac{1}{40}$) is used in acute inflammations of the bronchial tract. It produces copious diaphoresis. In doses of gr. j–ij it is used as an emetic in opium-poisoning.

Alumen (ALUM) is *potassium aluminum sulphate*, $K_2SO_4 + Al_2(SO_4)_3 + 24H_2O$. When heated gently it loses the water and forms *alumen exsiccatum*, dried alum.

PHYSIOLOGICAL ACTION AND USES.—Alum has marked local and systemic astringent effects. It diminishes secretion. In large doses it is an emetic. Dried alum is a mild escharotic. A solution of alum in nitric ether has been recommended in odontalgia, and, mixed with cinchona and myrrh, it has been employed for spongy gums, ulceration of the oral mucous membrane, and for relaxation of the tissues of fauces. It may also be used as a styptic after extraction of teeth. Alum should be excluded from dentifrices, as erosion of the enamel and dentine follows its prolonged use.

Acidum Tannicum (TANNIC ACID): dose, gr. j–xx.—Tannic acid, more correctly called tannin ($C_{14}H_{10}O_9$), occurs in pale yellow scales of a strongly astringent taste and having an acid reaction. It is freely soluble in water, alcohol, and glycerin, but is insoluble in pure anhydrous ether. It precipitates albumen and gelatin from solution, forming tannates with these substances. With ferric salts a blue-black precipitate is produced. Under the action of heat tannic acid is decomposed, with the formation of pyrogallic acid.

PREPARATIONS:

Collodium stypticum (tannic acid, 20; alcohol, 5; stronger ether, 20; collodion, 55 parts).

Unguentum acidi tannici (tannic acid, 1; benzoated lard, 20 parts).

Trochici acidi tannici (containing 1 grain of tannin in each troche).

Tannin and bodies analogous to it are found in many vegetable substances ordinarily known as astringents, such as kino (70 per cent.), nutgalls (65 per cent.), catechu (50 per cent.), krameria (43 per cent.), oakbark (11.21 per cent.). It is usually obtained from nutgalls, excrescences on a species of oak.

PHYSIOLOGICAL ACTION.—Taken into the mouth, tannin causes a peculiar sense of dryness of the tissues, and to a certain extent impairs for the time the sense of taste; these effects are due to coagulation of the albumen of the mucous membrane and to impairment of sensory power in the nerves, both of common and special senses distributed to the parts, by partial paralyses of their terminal filaments. When applied to the fauces and larynx the same effect is produced; hence its efficacy in allaying irritation in those parts. Upon the skin deprived of its epidermis similar effects are produced. The unbroken skin is but little influenced. Taken into the stomach, it combines with the pepsin of the gastric secretion, precipitating it from solution. In excessive amount it becomes an irritant and causes vomiting. Tannin is easily converted by fermentation into gallic and pyrogallic acids, and is so changed in the stomach before absorption. In these forms also it is excreted by the kidneys and intestinal canal. In the intestines it lessens secretion, diminishes peristaltic movement, and causes constipation. As an astringent tannin has generally been assumed to cause a lessening of the calibre of the capillaries through contraction of their muscular layers, but according to Brunton the vessels are dilated, tannin in this particular differing from other astringents, such as silver nitrate. Brunton states that the dilatation (first observed by Rossbach) is not due to paralysis of the coats of the arteries, since they contract in stimulation or on subsequent application of silver nitrate.

THERAPEUTICS.—The astringent effect of tannic acid when internally administered makes it a useful remedy in the relaxed conditions of the gastro-intestinal mucous membrane so often found in chronic diarrhœa and dysentery and in catarrh of the stomach or bladder. It is also used to check internal hemorrhage, as from the lungs, stomach, uterus, or kidneys. For this purpose, however, gallic acid is usually preferred. How either agent acts is not definitely known. For local use tannin is a very efficient hæmostatic, and one much employed in excessive hemorrhage after tooth-extraction. It can be very conveniently applied in the form of powder or the styptic collodion may be used. Either in powder or in solution it is much used in the treatment of diseased cutaneous and mucous surfaces where the tissues are inflamed or ulcerated or are relaxed, spongy, and the source of offensive discharges. In various skin diseases, among which eczema may be named, good results are often obtained, and in solutions of varying strength (grs. v–x in water f℥j) it is one of the most effective of applications in mercurial salivation, in aphthous ulcers of the mouth, spongy conditions of the gums, relaxed and inflamed conditions of the tonsils, uvula, fauces, nasal cavity, larynx, etc. Fungous growths of the gums and dental pulp may be effectively treated by a saturated solution of tannin (tannin ℥j, water f℥vj). This has a syrupy consistency and should be freely applied. A similar solution of tannin in alcohol is sometimes of service in the

treatment of sensitive dentine, and may be employed in cases of pulp-exposure, for which condition the following prescription (Druitt's) is sometimes useful:

℞. Acidi tannici, ʒj;
Mastich, grs. x;
Etheris, f℥ss.

S. Place on cotton in the carious cavity.

Tannic acid is of service in those conditions of hypersensitiveness of the teeth often following the removal of salivary calculus, the hyperæsthesia being due to the wounding of the peridental membrane and its exposure to irritating secretions. A similar condition is often set up as the result of the recession of the gingival margins and the consequent unprotected condition of the root-membrane. Frequently too forcible and prolonged pressure upon the gum from the clamps or ligatures used in holding in position the rubber dam is responsible for the trouble. For use in this class of cases a very strong solution of tannin (60 grs. to the ounce of water) should be employed, as in the mouth a weak solution of this kind is so rapidly diluted by the oral fluids as to soon become useless. A stronger solution longer resists this influence. The application is best made upon absorbent cotton twisted into a loose string-like form, with which, if possible, the tooth should be entirely encircled. The dressing should rest lightly upon the gum and against the root-membrane at the point of exposure; but pressure should be carefully avoided, as further recession would be the result. Some practitioners prefer for the purpose a saturated infusion of nutgalls. Such application should remain in position twenty-four hours and be renewed as occasion requires.

Acidum Gallicum (GALLIC ACID), $HC_7H_5O_5 + H_2O$, is a product of the fermentation of tannic acid. It forms white crystals soluble in water strongly astringent. It is generally preferred to tannic acid when a remote astringent effect is required, as in the treatment of passive hemorrhages, night-sweats, and chronic diarrhœa. The dose is gr. x–xv, but much larger amounts may be given.

The following substances, containing forms of tannic acid, have its physiological action and uses:

Galla, nutgall.
Tinctura gallæ: dose, f℥ss–ij.

Catechu, an extract from the wood of the *Acacia catechu.*
Tinctura catechu composita: dose, ♏x–f℥j.

Kino, the inspissated juice of the *Pterocarpus marsupium.*
Tinctura kino: dose, ♏x–f℥j.

Krameria (rhatany), the root of the *Krameria triandria* and *K. tomentosa.*
Extractum krameriæ: dose, gr. v–x.
Extractum krameriæ fluidum: dose, ♏v–xxx.
Tinctura krameriæ: dose, ♏v–ʒj.

Tincture of krameria is sometimes used as an astringent styptic mouth-wash after extraction of teeth.

Hæmatoxylon (logwood), *Geranium* (cranesbill-root), *Quercus alba* (white oak), *Rosa gallica* (red rose), *Rubus* (blackberry-root bark), are remedies of the same class.

Hamamelis (Witch-hazel) is the leaves of the *Hamamelis Virginica.* This remedy, long a favorite in domestic and eclectic practice, has of late been used in regular medicine. A preparation of it has for many years been sold under the title "Pond's Extract." The official preparation is—

Extractum hamamelidis fluidum: dose, ♏j–xxx.

Physiological Action and Therapeutics.—Hamamelis is astringent, styptic, and sedative. It has systemic effects outside of those due to its astringency. It has been used lately in hemorrhoids, venous congestions, varicose veins, and hemorrhagic discharges from the various mucous surfaces; also extensively in sprains, bruises, and indolent ulcers.

The fluid extract, used warm, is recommended as a local application in incipient dental periostitis, also as an anodyne to painful exposed pulps.

Colchicum.—*Colchici radix* is the bulb of the *Colchicum autumnale; Colchici semen* is the seed of the same plant. Both plants contain tannic and gallic acid, together with an alkaloid, *colchicine* ($C_{17}H_{19}NO_5$), which latter is the active principle.

Preparations:

Extractum colchici radicis fluidum: dose, ♏ij–v.
Vinum colchici radicis: dose, ♏v–xv.
Extractum colchici radicis: dose, gr. ss–ij.
Extractum colchici seminis fluidum: dose, ♏j–v.
Vinum colchici seminis: dose, ♏x–f℥ss.
Tinctura colchici (from seed): dose, ♏x–f℥ss.

Physiological Action.—Colchicum increases the mucous and glandular secretions, and in full doses produces nausea, vomiting, depression of the circulation, headache, and often purgation. It increases the action of the kidneys and the skin. In large doses it acts as a poison.

Therapeutics.—Colchicum is used at the present time almost entirely in the treatment of gout. It is also serviceable in the so-called rheumatic gout and the affections associated with the gouty diathesis, but it is not advised in acute rheumatism. In congestive cerebral disorders it is sometimes given as a drastic purgative.

Colchicum may be used in the treatment of gouty inflammations of the peridental membrane. (See Vol. I. p. 979.)

Sarsaparilla, the root of several species of *Smilax*, and

Guaiacum, the heart-wood of the *Guaiacum officinale*, are two substances once largely in favor as alteratives in the treatment of syphilis and scrofula, but they are now replaced by more efficient remedies. *Tinctura guaici*, in half-drachm doses every four hours, is very serviceable in tonsillitis.

Stillingia is the root of the *Stillingia sylvatica.* The active principle has not been isolated.

Preparation:

Extractum stillingiæ fluidum: dose, ♏x–f℥j.

Physiological Action and Uses.—Stillingia promotes the action of the kidneys, skin, and mucous membrane. In full doses it excites nausea and vomiting, and increases the heart's action. It is supposed to have alterative powers, and is used in syphilitic and scrofulous diseases and in the various disorders, such as constipation and hemorrhoids, dependent upon or associated with torpidity of the liver. It is advantageously used with quinine or arsenic in the treatment of malarial conditions.

Sanguinaria (Bloodroot) is the rhizome of the *Sanguinaria Canadensis,* an indigenous herb. The rhizome has a deep blood-red color, and contains several alkaloids—one of which, *sanguinarine,* is the active principle.

Preparations:

Tinctura sanguinariæ: dose, ♏v–xxx.
Extractum sanguinariæ fluidum: dose, ♏ij–xx.
Acetum sanguinariæ: dose, ♏v–xxx.

Physiological Action and Uses.—Sanguinaria has a persistent bitter taste. Its powder is somewhat escharotic. In full doses it is an irritant poison, causing nausea and vomiting, inflaming the gastric mucous membrane, and sometimes producing prostration and collapse. In moderate doses it increases the secretion of the mucous surfaces. It is employed in atonic dyspepsia and in diseases of the respiratory organs. The local application of the powder has been found beneficial in nasal catarrh, and from its escharotic effect it is serviceable in the treatment of exuberant granulations or unhealthy ulcers. It is credited with aphrodisiac and emmenagogue properties. It is rather too violent for use as an emetic.

Xanthoxylum (Prickly Ash) is the bark of the *Xanthoxylum fraxineum* and *X. Carolinianum.* The official preparation is

Extractum xanthoxyli fluidum: dose, ♏x–ʒj.

Physiological Action and Uses.—Prickly ash has a highly stimulant action on the salivary glands, and is supposed to stimulate in the same manner both by local and systemic action the glands of the digestive tract. It also increases the heart's action and promotes perspiration and secretion of urine. This eliminant action renders it useful in rheumatism chronic and muscular, dropsy, jaundice, syphilis, and chronic malarial conditions. It is a domestic remedy for toothache, and a decoction of the bark is used locally in chronic pharyngitis attended with dryness of the throat.

Agents which Cause some Evacuation from the Body.

Cathartics or Purgatives.—Under these terms are included a considerable number of remedies the typical action of which is to cause evacuation of the contents of the bowels. The members of the group differ considerably in the degree and manner of their action, and may be classified as follows:

1. *Laxatives.*—These are mild in their action, producing their effects

by slightly stimulating the muscular coat of the bowels without any marked irritative effects; they at the same time increase to a limited extent the secretions.

2. *Mild Cathartics.*—By these a more pronounced action is effected. Peristalsis is decidedly increased and the secretions of the intestinal glands much augmented.

3. *Drastic Cathartics.*—These are still more powerful, and produce marked irritation; the peristaltic movements become violent in character, and are accompanied by some griping pains and tenesmus. The discharges are profuse and watery—a result due both to increased secretion and to the osmosis of the serum through the blood-vessels distributed to the irritated intestinal tract.

4. *Saline Cathartics.*—These are mildly purgative in character, but the ejections they produce are loose and watery, as they actively stimulate the intestinal secretions.

5. *Hydragogue cathartics* act with marked energy, causing a profuse outward osmosis through the intestinal blood-vessels, and at the same time greatly stimulating the glandular secretions and increasing peristalsis. Hence the stools are profuse and watery.

6. *Cholagogue cathartics* are those which act on the upper part of the bowel, and either produce some stimulation of the liver or reflex excitation of the gall-ducts and bladder, causing them to contract and expel their contents, thus increasing the flow of bile and producing greenish stools.

LAXATIVES.

The following list includes the more important laxatives, with their doses:

Magnesia, magnesium oxide, MgO: dose, gr. x–ʒj.
Magnesii carbonas, magnesium carbonate, $MgCO_3$.

ACTIONS AND USES.—These agents are antacid as well as laxative. In order to produce a laxative effect they must enter into combination with the acids of the stomach, thus forming magnesium salts. As cathartics, magnesia and its carbonate are otherwise inert, and if freely administered may accumulate in dangerous amount in the intestines, where they form concretions. A cathartic effect can be given to magnesia by combining it with citric acid, as in the official *liquor magnesii citratis*, the dose of which is of f℥iij–vj. As purgatives, magnesia and its preparations are not very reliable, but they are often of use in sick headache where there is gastric acidity as well as constipation, and, owing to their antacid properties, they are sometimes combined with other purgatives. The antacid quality of magnesia makes it an excellent basis for a dentifrice.

Manna.—Manna is a concrete saccharine exudation obtained by making incisions in the bark of the *Fraxinus ornus*, or manna ash. It occurs in the form of flakes, and contains about 90 per cent. of a non-fermentable sugar, mannite, $C_6H_{14}O_6$, and also a fermentable sugar, a resin, and mucilage. Manna is mildly laxative, but has a tendency

to produce flatulence and colic. It is usually given in combination with rhubarb or senna.

Cassia Fistula (Purging Cassia) is the fruit of the *Cassia fistula*, a tropical tree. Only the pulp of the fruit is active: dose, ʒj–ij. It is laxative, but owing to its tendency to gripe is usually given in combination with manna or senna. It forms an ingredient in the official *Confectio sennæ.*

Cascara Sagrada (unofficial).—This is the bark of the *Rhamnus Purshiana*, or California buckthorn. It contains several resins, tannic, malic, and oxalic acids, and a neutral crystalline substance. A fluid extract, dose fʒss–j, has been prepared, and is found to be a mild laxative, producing free evacuations.

Sulphur.—*Sulphur lotum*, washed sulphur; *sulphur præcipitatum*, precipitated sulphur: dose of each, grs. x–ʒj.

Actions and Uses.—Sulphur is mildly laxative, slightly stimulating the intestinal secretions. It is often combined with saline cathartics, and, as it renders the stools softer, is useful in fissure of the anus and hemorrhoids.

In addition to the medicinal agents above enumerated, all fresh ripe fruits are more or less laxative, as are dried figs, prunes, and tamarinds; so too are expressed almond and olive oil, soap, glycerin, honey, oatmeal, and unbolted wheat flour. Belladonna, stramonium, and hyoscyamus stimulate the intestinal secretions, and are often given in combination with other agents for their mildly laxative effect.

MILD CATHARTICS.

Aloe (Aloes) is the inspissated juice of the leaves of the *Aloe Socotrina.* It contains a bitter precipitate, *aloin*, and a volatile oil.

Preparations:
- *Aloe purificata:* dose, gr. j–v.
- *Extractum aloes aquosum:* dose, gr. ss–iij.
- *Tinctura aloes:* dose, fʒss-ij.

There is also a large number of pilular preparations into the composition of which aloes enters.

Physiological Action and Uses.—Aloes is principally important as a purgative acting chiefly on the lower half of the large intestine. In small dose it is a tonic and stimulant to the liver. In large doses its action may be very severe. It is used principally for chronic constipation, jaundice, atonic dyspepsia, and in hemorrhoids not associated with active pelvic congestion. It is usually given in small doses with nux vomica. Its action is slow, ten or twelve hours being often required for catharsis. The cathartic principle diffuses into the blood, and will produce purgative effects through the milk of nursing women.

Rheum (Rhubarb) is the root of the *Rheum officinale.* In addition to a cathartic and a bitter principle, it contains several organic substances of complex chemical character. Among these is rheo-tannic

acid and a rhubarb resin. Rhubarb is an ingredient in many of the compound purgative preparations. It will be necessary only to give a few of the simpler forms. The dose of the drug itself in powder is about gr. xv.

PREPARATIONS:
Extractum rhei: dose, gr. xij.
Pilulæ rhei, each pill contains gr. iij of the drug.
Syrupus rhei aromaticus: dose, f℥j–iv.
Mistura rhei et sodæ: dose, f℥ij–f℥j.
Tinctura rhei: dose, f℥j–ij.

ACTION AND USES.—Rhubarb has tonic and astringent as well as purgative properties; and this fact makes it a desirable remedy in cases where atonic indigestion has resulted in diarrhœa due to the accumulation of undigested food in the intestines: peristaltic movement is increased and the bowel speedily cleared, while the tonic-astringent properties of the drug serve to diminish exudation and restore tone to the digestive function. Rhubarb never produces gastro-enteric inflammation. It is an excellent remedy in cases of hemorrhoids attended by constipation. In small doses it will improve the appetite and promote digestive power, without producing a cathartic effect, and the tincture is often given to meet these indications. As is the case with aloes and many other cathartics, purgative properties are communicated to the milk of nursing women by rhubarb through absorption into the circulation.

Senna is the leaflets of the *Cassia acutifolia* and *C. elongata.* It contains several non-basic organic principles.

PREPARATIONS:
Extractum sennæ fluidum: dose, f℥j.
Syrupus sennæ: dose, f℥j–ij.
Confectio sennæ: dose, ℥j–ij.
Infusum sennæ compositum, "black draught:" dose, f℥ij–iv.

Senna enters into the compound licorice powder and compound syrup of sarsaparilla.

ACTION AND USES.—Senna is a prompt and efficient cathartic, producing, however, some griping pain, which may be diminished by the use of hyoscyamus or belladonna. It produces copious discharges, and does not leave the bowels in an exhausted condition. It is much used in the treatment of constipation in children. The odor and taste, being very disagreeable, are serious objections to its use. Prunes stewed in an infusion of senna constitute a good laxative for use with children. In large doses senna produces nausea and vomiting. It is not recommended in cases of fever or of great irritation of the intestinal mucous membrane.

Oleum Ricini (CASTOR OIL) is the expressed oil of the seed of the *Ricinus communis.* It is used in doses of f℥j–iv. It is usually regarded as a mild and harmless cathartic, and is extensively used in domestic medicine in the treatment of constipation of pregnant women and of children. It is also much used in the diarrhœa of indigestion. Although generally regarded as harmless as a cathartic, there is reason to believe that it may be decidedly irritating. The seeds contain an ingredient capable of producing severe cholera morbus, and the irritating effects

produced by some specimens of the oil may be in part due to the method of preparation. The taste is exceedingly disagreeable to most persons, but may be masked to a great extent by some strongly effervescent drink.

DRASTIC CATHARTICS.

Jalapa (JALAP) is the tuberous root of the *Exogonium purga.* It contains two resins—*jalapin* and *convolvulin*—existing in combination in the official *resina jalapæ.* These resins are the active ingredients of the drug.

PREPARATIONS:
Abstractum jalapæ: dose, gr. j–v.
Resina jalapæ: dose, gr. ij–v.
Pulvis jalapæ compositus: dose, gr. x–ʒj.

ACTION AND USES.—In medicinal doses jalap causes copious watery evacuations attended by considerable intestinal pain. It increases the intestinal secretions. In combination with calomel it was at one time in great favor. It is still much employed at the onset of fevers and inflammations, and as an evacuative in dropsical affections.

Colocynthis (COLOCYNTH), the peeled fruit of the *Citrullus colocynthis.* Its active principle is a non-basic body, *colocynthin.*

PREPARATIONS:
Extractum colocynthidis: dose, gr. $\frac{1}{2}$–ij.
Extractum colocynthidis compositum: dose, gr. v–xx.

ACTION AND USES.—Colocynth increases intestinal peristalsis and stimulates secretion, producing watery discharges attended by colic. It is generally used in association with other purgatives. It is employed when an active depletory purgative is required, as in dropsy.

Elaterinum (ELATERIN) is a substance deposited from the juice of the fruit of the *Ecballium elaterium,* or "squirting cucumber:" the active principle is *elaterin.* The dose of elaterinum is gr. $\frac{1}{20}$–$\frac{1}{12}$, and it is generally used either in the form of a trituration or of granules. It produces profuse watery discharges, and is one of the most effective of its class for a derivative effect in cerebral or pulmonary inflammation, but must be used with caution, as it may cause great debility. As it produces profuse serous discharges, it is often given in dropsies to drain the system of fluids.

Cambogia (GAMBOGE) is a gum-resin well known as a pigment. It is drastic as a cathartic and produces watery stools, but is now rarely used alone. The dose of the powdered drug is gr. ij–iv.

Scammonium (SCAMMONY) is a resinous exudation from the root of *Convolvulus scammonia.* It consists largely of a mixture of resins similar to those contained in jalap.

PREPARATION:
Resina scammonii: dose, gr. iij–viij.

PHYSIOLOGICAL ACTION AND THERAPEUTICS.—Scammony is an active cathartic, and in large doses irritating. By some it is considered

an effective anthelmintic in cases of tape-worm, and owing to its tastelessness it has been used as a purgative for children, but is very rarely employed alone.

Oleum Tiglii (Croton Oil) is the fixed oil expressed from the seed of the *Croton tiglium.* In doses of one to two drops it produces drastic cathartic effects, peristalsis being greatly increased and the evacuations being copious and watery. In excessive doses it may produce violent intestinal inflammation, and must not be given in inflammatory states of the intestinal tract or in cases of debility. As a cathartic it is often employed when more bulky drugs are difficult of administration, as is sometimes the case with recalcitrant prisoners or insane persons; and it is so prompt in its action that it is used when immediate depletory and revulsive results are called for, as in cases of apoplexy. In lead colic it is one of the most efficient of purgatives, and, like the other drastics, is often employed in dropsy. Applied to the skin, croton oil produces a characteristic eruption—at first in the form of red pimples, which rapidly become pustular. Thus applied, it is capable of absorption and of producing purgative effects. The application, however, is usually made to produce counter-irritation. For this purpose the oil is usually diluted with almond oil or with five or six times its volume of turpentine.

SALINE CATHARTICS.

The principal saline cathartics are—

Magnesii sulphas, magnesium sulphate (Epsom salt), $MgSO_4 + 7H_2O$, a salt occurring in small colorless rhombic prisms, very soluble in water and of a bitter saline taste: dose, ʒj–℥j.

Magnesii citras granulatus, granulated magnesium citrate: dose, ʒij–℥j.

Liquor magnesii citratis: dose, f℥iij–vj.

Potassii et sodii tartras, potassium and sodium tartrate (Rochelle salt), $KNaC_4H_4O_6 + 4H_2O$.

Pulvis effervescens compositus, compound effervescing powder (Seidlitz powder), made by placing in one paper Rochelle salt 120 grs. and sodium bicarbonate 40 grs., and in another paper tartaric acid 35 grs., the contents of each paper to be dissolved in a separate glass of water, and the contents of the two glasses to be mixed at the time of taking.

Sodii phosphas, sodium phosphate, $Na_2HPO_4 + 12H_2O$: dose, ʒss–℥ss.

Effects and Uses.—Saline cathartics may be either laxative, mildly purgative, or drastic, according to the dosage. In general terms, it may be stated that they are not apt to create nausea or great intestinal irritation, as is the case with many other purgative medicines, and for this reason are indicated when mild effects are desired. They but slightly increase peristalsis, and this chiefly by mechanical distension of accumulated intestinal secretions, which secretions are greatly augmented, copious watery stools being produced, thereby establishing a drain upon the intestinal vessels and diminishing the volume of fluid in the entire circulation and lowering arterial tension.

For these reasons salines are highly advantageous in acute inflamma-

tions and in febrile conditions generally. In addition to their direct action on the intestinal tract, they often excite the kidneys to increased activity, either by direct stimulation of those organs through their absorption into the blood and elimination with the urine—a result which may be obtained by giving the salt in very dilute solution and keeping the skin cool—or by reflex stimulation or by a lessening of hyperæmia in renal congestion.

The most powerful and effective of the salines is undoubtedly the magnesium sulphate; in practice it is much employed, not only to relieve the intestines of accumulated fecal matter and in the treatment of inflammatory and febrile states, but also in renal and cardiac dropsy, for the purpose of securing the absorption of effused fluids. By many purgation with this salt is considered highly advantageous in the early stages of acute dysentery, for which use it is given in small doses, repeated at short intervals until the medicine operates, the solution of the salt being frequently combined with a few drops of dilute or aromatic sulphuric acid.

In dental practice Epsom salt enjoys a like pre-eminence, and is the one most frequently administered in acute inflammations of the peridental membrane or of the dental pulp. In favorable cases the treatment, when assisted by proper surgical procedures and local depletion or counter-irritation, is often successful. In the more severe types of inflammation, however, the effects of the salt are too slight and transitory to be very effective, for, as shown by Brunton, while the saline solution in the intestine causes increase of its secretions, and a corresponding diminution of the fluids of the blood and a lessening of arterial tension, the blood is restored after a short time by absorbing from the tissues a nearly equal quantity of their fluids. Hence the feeble curative power of such agents as compared with such sedatives or motor depressants as opium or aconite, by which repressive power over the circulation may be indefinitely prolonged.

As adjuncts to the latter forms of treatment the salines are of the highest service, and it is especially advantageous to give a full dose of Epsom salts the day following the administration of opium, both to overcome the constipation produced by that drug and to still further relieve local congestion. As magnesium sulphate causes but little increase of peristaltic movement, and as the effused fluids are for this reason sometimes so long retained in the intestine that they are reabsorbed, it is often advisable, in order to effect free purgation, to combine the saline with senna, as in the official compound infusion of that drug (*infusum sennæ compositum*), the dose of which is from two to four fluidounces every three or four hours until the desired effect has been produced. The condition of administration most favorable for securing a free outward osmosis of intestinal fluids is that the saline solution shall be a strong and not a dilute one, as it is a well-established osmotic law that a dense fluid (saline solution) upon one side of a membrane favors diffusion into that fluid of the less dense fluid (serum of the blood) upon the opposite side of the membranous wall. As shown in the paper on Reflex Neurosis (see p. 441), fecal accumulations are often the occasion of reflex dental disturbances, and under such conditions a

full dose of magnesium sulphate combined with senna is a safe and efficient purgative.

HYDRAGOGUE CATHARTICS.

As has been said, all the salines have a hydragogue effect when given in large doses, but those drugs usually classed as hydragogue cathartics not only cause accumulations of fluid in the intestines, but also greatly excite the peristaltic movement, so that such accumulations are as rapidly ejected as formed. Elaterium, croton oil, and gamboge, already described as drastics, are the best representatives of this class. They are chiefly employed in the treatment of dropsy or as revulsives in cerebral congestions or effusions.

CHOLAGOGUE CATHARTICS.

Podophyllum (May Apple), the rhizome of *Podophyllum peltatum*, an herbaceous perennial plant found in the United States and Canada.

Preparations:
Abstractum podophylli: dose, gr. $\frac{1}{4}$–j.
Extractum podophylli: dose, gr. v–x.
Extractum podophylli fluidum: dose, ♏j–xx.
Resina podophylli (podophyllin): dose, gr. $\frac{1}{8}$–j.
This must be carefully distinguished from the crude drug podophyllum.

Effects and Uses.—Podophyllum is the most powerful agent of the cholagogue group. It increases the flow of bile and stimulates the intestinal secretions, but is slow in its action, requiring from six to ten hours before effecting purgation, and is liable to produce nausea and griping, to counteract which tendencies it can be advantageously combined with belladonna or hyoscyamus. To hasten catharsis it can be administered with other cathartics. The resin of podophyllum is the most used of the preparations, and is frequently employed in constipation with torpidity of the liver and deficiency of intestinal secretions, and has to a great extent displaced calomel and blue mass from favor.

Mercurials.—Several mercurial compounds are cholagogues.

Hydrargyri chloridum mite, mercurous chloride, calomel, Hg_2Cl_2: dose, gr. v–xx.
Massa hydrargyri, blue mass (metallic mercury with a confection): dose, gr. j–xx.
Hydrargyrum cum creta (mercury with chalk): dose, grs. iij–x.

Until a recent period these preparations of mercury have been regarded as cholagogue, but the results of modern physiological experimentation indicate that they do not exert a specific influence in stimulating the hepatic cells, but act by excitation of the intestinal glands and by reflex irritation of the bile-ducts. (See Mercury.) Given alone, they are often slow and uncertain in action, and the general practice is to either administer them in conjunction with, or follow them by, other cathartics. The dangers of accumulation in the system, and consequent mercurial poisoning, which are such strong objections to the employment of mercurial preparations, are thus greatly lessened. A good cathartic combination is that of the well-known *pilulæ catharticæ compositæ* (compound cathartic pills), often sold as "antibilious pills," which contain, in addi-

tion to calomel (1 gr. to each pill), colocynth, jalap, and gamboge. To produce active catharsis in an adult three pills are required.

Mercury with chalk was formerly much employed in the treatment of infantile diarrhœa with colorless stools, with a view to stimulating the liver, the chalk being useful chiefly, if not solely, as a means of securing a minute subdivision of the mercury. Safer remedies are now generally employed.

As aloes and rhubarb, already described as mild cathartics, have some effect in stimulating the hepatic secretion, they may also be classed as cholagogues.

Enemata, or **Clysters,** are rectal injections. These are frequently employed to produce evacuation of the intestinal contents, and are of excellent service in cases of obstinate constipation or when the lower bowel is impacted with feces. Enemata act chiefly by reflex irritation of the bowel set up by contact of its surface with, and distension of its walls by, the injected fluid, with the result that the muscular fibre of the intestine is thrown into contraction. Sometimes purgative substances, such as aloes or magnesium sulphate, are thrown into the bowel with a view to their absorption into the circulation and the production of a specific effect upon the entire intestinal canal. Such enemas are of doubtful efficacy, except for a purely local effect. The enemata most frequently employed are of a simple character, such as warm water having in solution either soap or common salt, or both. The volume of the injection should vary with the age of the patient and the condition of the bowel. For an adult from a pint to a quart of fluid may be employed, or even a much larger amount if carefully introduced; for infants and children, from half an ounce to six ounces according to age. In administering a rectal injection the bulb syringe known as Davidson's is best. The nozzle should be oiled to facilitate its introduction, which should be effected with great care, in order to avoid inflicting injury or pain upon the patient. The injection should be thrown in with gentle pressure, as undue violence might cause severe injury or even rupture of the intestine. With proper precautions the large intestine may be thoroughly washed out and freed of impacted fecal accumulations—a procedure from which the greatest possible advantage has been derived in cases of obstinate constipation depending upon torpidity of the muscular layer of the intestinal wall. The expulsion of fecal matter in such cases is greatly expedited by a gentle kneading of the bowel through the abdominal parietes.

Emetics.

Emetics are agents which produce nausea and vomiting. They are administered—1st, to relieve an overloaded condition of the stomach; 2d, to remove from the stomach unhealthful and poisonous substances; 3d, to assist in dislodging false membranes from the trachea by muscular contraction; 4th, to expel foreign bodies from the pharynx or œsophagus; 5th, to produce general muscular relaxation as the effect of excessive nausea.

Vomiting may be excited either by an irritant application to the

gastric nerves, or to the branches of the pneumogastric distributed to the fauces, or by specific stimulation of the nerve-centres situated in the medulla oblongata which controls and co-ordinates the movements necessary to the performance of the act of emesis. These movements consist in the simultaneous contraction of the abdominal walls and of the diaphragm upon the stomach, the cardiac orifice of which is at the same time caused to dilate by the contraction of muscular fibres passing from its walls to the lower end of the œsophagus. By this contraction not only does the dilatation in question occur, but the stomach is drawn up against the diaphragm, the pressure of which upon the stomach is thereby increased, that organ being thus forcibly compressed between the unyielding diaphragm and the forcibly contracted abdominal muscles. This series of reflex acts is coincident with or immediately preceded by a deep inspiration, distending the lungs, which thus press upon the diaphragm, and a spasmodic closure of the glottis, this preventing the escape of air and also preventing the admission of vomited matter into the trachea. When the co-ordination of these movements is not complete, they are ineffective, and retching instead of vomiting is the result.

Emetics may be divided into two classes—*local emetics*, which produce irritation of the gastric nerves and a reflex excitation of the vomiting nerve-centre; and *systemic emetics*, which, being absorbed into the circulation, act specifically and directly upon that centre. The principal local emetics are—

Cupri sulphas, copper sulphate, blue vitrol, $CuSO_4 + 5H_2O$: dose, gr. iv–viij.
Zinci sulphas, zinc sulphate, white vitriol, $ZnSO_4 + 7H_2O$: dose, gr. x.
Hydrargyri sulphas flava, basic mercuric sulphate, $Hg_2O_2 + HgSO_4$: dose, gr. iij.
Alumen, common alum: dose, ʒj–ij.
Sinapis alba and *sinapis nigra*, white and black mustard: dose, ʒj–ij.

These irritant emetics are used for the purpose of relieving an overloaded stomach or of expelling poisonous substances. In the doses given above they are harmless, but in cases of insensibility, as from opium-poisoning, repeated doses may be required, and the mineral irritants must be given with care or a condition of irritant poisoning will supervene.

Warm and salt water are well-known mild emetics. Copper sulphate and zinc sulphate are administered dissolved in water; zinc sulphate is the less irritating. Basic mercuric sulphate and mustard are given, stirred together, in warm water. This is often highly advantageous in the early stages of croup.

Vomiting can be caused not only by the administration of emetics, but by local irritation of the fauces with a feather or a finger. Disgusting sights or smells may, acting through the nerves of special sense, produce such mental impressions as to excite the vomiting centre in the medulla. Vomiting, too, may be a symptom of, and caused by, gastric inflammation or occur as the result of brain lesions.

SYSTEMIC EMETICS.

Ipecacuanha (Ipecac) is the root of the *Cephaëlis ipecacuanha*. The active principle is an alkaloid, *emetine*.

PREPARATIONS:

Vinum ipecacuanhæ: dose, ♏j–xxx.
Syrupus ipecacuanhæ: dose, f℥j–iv.
Extractum ipecacuanhæ fluidum: dose, ♏j–xx.
Emetine (unofficial): dose, gr. $\frac{1}{120}$–$\frac{1}{40}$, as expectorant; as emetic, gr. $\frac{1}{8}$–$\frac{1}{4}$.

Ipecacuanha enters into Dover's powder (*pulvis ipecacuanhæ et opii*) (opium, gr. j; ipecacuanha, gr. j; sugar of milk, gr. viij).

PHYSIOLOGICAL ACTION AND THERAPEUTICS.—When applied to the skin ipecacuanha causes irritation, and sometimes a pustular eruption. It is also a local irritant to the respiratory tract. Taken internally in minute doses, it may stimulate the gastric secretions, and act as a stomachic tonic, and will sometimes even allay nausea and vomiting; but in full doses, grs. v–xx, it is irritant to the stomach, and produces prompt emesis, this result being due both to direct action upon the terminals of the vagus in the gastric mucous membrane and to its action on the vomiting centre by absorption into the circulation. Upon the force of the circulation ipecacuanha exerts but slight influence, but it relaxes the pores of the skin, thereby favoring diaphoresis, and also stimulates the mucous secretion of the bronchial passages; hence it is both diaphoretic and expectorant, and in small doses is often employed to produce those effects when indicated. As a diaphoretic it is much employed in the treatment of inflammatory and febrile conditions, such as muscular rheumatism and acute catarrh of the nasal and bronchial passages, for which use it is generally combined with opium, as in Dover's powder. Its expectorant properties render it useful in bronchial inflammation with scanty secretion of mucus, and it is often an ingredient in cough mixtures.

As an emetic it acts promptly and efficiently, and without producing much depression, and is much employed in cases of poisoning or to relieve an overloaded stomach. Its action is greatly facilitated by copious draughts of lukewarm water, and the powdered root is best administered by stirring it in water at that temperature. In diphtheria and croup also it is given to mechanically clear the trachea and larynx of membranous exudations.

In dental practice its employment is almost entirely confined to its administration in combination with opium in the treatment of inflammation of the peridental membrane. (See OPIUM.)

Antimonii et potassii tartras, antimonium and potassium tartrate, $K(SbO)C_4H_4O_6 + H_2O$. Tartar emetic is a powerful emetic in doses of one to three grains, but owing to its often dangerously depressing effect it is now rarely used for such purposes. It is described elsewhere under ANTIMONY.

Apomorphinæ Hydrochloras (dose, gr. $\frac{1}{16}$–$\frac{1}{8}$), $C_{17}H_{17}NO_2HCl$, is a derivative of morphine. It is one of the most prompt and efficient of the systemic emetics. It produces but little nausea, and acts whether taken into the stomach or injected under the skin. The latter fact renders the agent of great service in cases where the stomach is inflamed or when for any reason the introduction of an emetic into the stomach is difficult or impossible, and prompt action is necessary. When hypodermically administered, from five to twenty-five minutes may elapse before vomiting is induced. One-sixteenth of a grain is usually sufficient for the

purpose. When given by the stomach a larger dose (gr. $\frac{1}{8}$) and a longer time are required. Apomorphine hydrochlorate is a good emetic to administer when the prompt emptying of an overloaded stomach becomes necessary: the contents of the stomach are usually thoroughly evacuated. But in narcotic poisoning it will not act unless given before the nervous system has become fully narcotized.

Scilla (squill) is also a systemic emetic, but is chiefly used as an expectorant.

Anthelmintics.

Anthelmintics are remedies which destroy or expel parasitic animals from the intestinal canal. The following are the more important:

Santonica, the unexpanded flower-heads of the *Artemisia maritima. Santonin* is the active principle, the dose of which is gr. $\frac{1}{4}$ to iij.

Chenopodium (Wormseed) is the fruit of the *Chenopodium ambrosioides.* It contains a volatile oil, *oleum chenopodii,* of which the dose is ♏v–x.

Spigelia (Pinkroot) is the root of *Spigelia marilandica:* dose of the fluid extract, ♏x–f℥j.

Aspidium (Male Fern) the rhizome of the *Aspidium filix mas:* dose of the oleoresin, *oleoresina aspidii,* ♏v–xxx.

Granatum (Pomegranate), the bark of the *root* of the *Punica granatum.* It is given freely in decoction (for tape-worm).

Pepo (Pumpkin-seed), the seed of the *Cucurbita pepo,* given freely in decoction (for tape-worm).

Diuretics.

These are remedies which by stimulating the circulation of the kidneys cause increased urinary secretion. The skin and kidneys bear a vicarious relation to each other, and what promotes the action of the one may diminish the action of the other. Thus, if perspiration be very active, the urine will be decreased; a sudden check to the action of the skin will cause an increase in the secretion of urine. This physiological fact is often taken advantage of in case of kidney disease, in which, by promoting the action of the skin, relief is given to the diseased organ or the accumulation of effete matter is prevented.

Terebinthina (Turpentine), an oleo-resin from various species of pine.

Oleum terebinthinæ, $C_{10}H_{16}$, the volatile oil of turpentine: dose, ♏v–f℥ss.

Physiological Actions.—Oil of turpentine in small doses increases the action of the heart and the tension of the arteries. It diffuses through the system with great rapidity, and soon appears in the secretions. The vapor, inhaled, produces headache. In large doses it pro-

duces gastro-enteric inflammation, fever, muscular weakness, delirium, and partial insensibility. Doses of four or five ounces have been given without fatal result. Oil of turpentine is prone to take up oxygen, especially ozone, and by this means becomes a powerful germicide. A highly ozonized preparation of this character is now used under the name "Sanitas Oil." In the ozonized state the oil prevents the slow oxidation of phosphorus, and is used both as a preventive and antidote to phosphorus-poisoning. It is excreted by the different excretory organs, especially the kidneys, and thus produces a diuretic effect. Applied to the skin, it is a rubefacient.

THERAPEUTICS.—Oil of turpentine is used for flatulence and colic, intestinal catarrh, constipation, and as an anthelmintic. It is excellent in passive hemorrhages from the mucous surfaces, and as a vaso-motor stimulant in low fevers. Turpentine enemata are frequently used in colic, tympanitic distension, and impaction of feces. It is useful in affections of the bronchial and pulmonary mucous membrane. Externally it is employed as a remedy for hospital gangrene and as a counter-irritant in internal inflammation and neuralgias. Inhalations of the vapor have been used in laryngeal and bronchial affections.

Terebene is a colorless liquid obtained by the action of sulphuric acid on turpentine. It resembles turpentine in most of its physiological properties, and is less irritating: dose, ♏v–xx.

The following are additional remedies of the diuretic class:

Copaiba is the oleo-resin of several species of *Copaifera:* dose, ♏x–ʒj; of the oil, ♏v–fʒss.

Cubeba (CUBEB) is the unripe fruit of the *Cubeba officinalis:* dose, gr. x–ʒij; of the oil, *oleum cubebæ,* ♏v-fʒss.

As diuretics copaiba and cubebs are decidedly stimulant.

Buchu is the leaves of various species of *Barosma:* dose, gr. xv–xxx.

Uva Ursi (BEARBERRY) is the leaves of the *Arctostaphylos uva ursi:* dose, gr. x–ʒj.

Pareira is the root of the *Chondodendron tomentosum:* dose of the fluid extract, fʒss–j.

Chimaphila (PIPSISSEWA) is the leaves of the *Chimaphila umbellata:* dose of the fluid extract, fʒss–ij.

Scoparius (BROOM), the tops of the *Sarothamnus scoparius.* No official preparations. The plant contains a liquid alkaloid, *sparteine,* $C_{15}H_{26}N_2$, which appears to have the power to increase the force and duration of the contractions of the heart and to regulate a disturbed cardiac rhythm, its effects appearing sooner and lasting longer than is the case with those of digitalis or belladonna. The alkaloid does not appear to be markedly diuretic. The plant is a tonic astringent diuretic, like buchu, uva ursi, pareira, and chimaphila. It seems to be suitable for use in cardiac weakness. The alkaloid is given in the form of sulphate in doses of 1 grain three times daily.

Juniperus (JUNIPER) is the fruit of the *Juniperus communis.* It is a stimulant diuretic, and in large doses may produce renal irritation. The oil, *oleum juniperi,* is official: dose, ♏v–xx.

Scilla (SQUILL) is the bulb of the *Urgenea scilla:* dose, gr. j–iij.

In large doses it may produce great irritation of the kidneys, with strangury and bloody urine. The syrup, *syrupus scillæ,* is the principal preparation: dose, f℥ss–j.

TOPICAL REMEDIES.

Topical remedies are those which act upon the part to which they are applied. They may be divided into several classes, as follows:

1. Those which produce some local irritation or stimulation with or without absorption;
2. Those which act upon the tissues destructively or corrosively;
3. Those which produce destruction of parasitic or microscopic growths that may be in the tissues.

To this third class belongs the now important and increasing group of germicides.

The first group includes the remedies commonly known as COUNTER-IRRITANTS, and is usually divided into two sub-groups: *Rubefacients,* which cause irritation and congestion of the skin, and may, if concentrated or long applied, produce deeper changes; *Epispastics,* which are more powerful, always exciting inflammation and blistering. Although apparently differing in degree, only the more powerful action of the remedies of the second group enables effects to be produced remote from the point of application and induces marked reflex symptoms. This is seen in the case of extensive burns, which may produce inflammatory changes in the internal organs far removed from the seat of actual injury.

RUBEFACIENTS.

Sinapis alba (WHITE MUSTARD) is the seed of the *Sinapis alba;*

Sinapis nigra (BLACK MUSTARD) is the seed of the *Sinapis nigra.* These differ somewhat in their chemical composition. The irritating qualities of black mustard are due to the production of a volatile oil by the reaction between certain products in the seed when moistened with cold water. Boiling water prevents the action, and hence the irritant qualites are not developed by it. White mustard in the same way, by a reaction between several products, produces an irritating oil. These are sulphuretted oils of complex formulæ.

PHYSIOLOGICAL ACTION AND USES.—The rubefacient action of mustard is well known. When its application is long continued it may produce serious local inflammation. Internally used in full doses, it is an emetic. It acts upon the mucous membrane much less powerfully than upon the skin. It is very largely used as an application to relieve pain and to stimulate the action of the internal organs in neuralgias, colic, various inflammations, and also as a derivative in cerebral congestion. As an emetic it is not infrequently used in cases of poisoning.

A number of other remedies of the same general nature as mustard are employed in medicine. Among these are *emplastrum capsici, emplastrum resinæ, emplastrum saponis, emplastrum arnicæ, Burgundy pitch plaster, and Canada pitch plaster.*

The application of various household spices in combination, such as cloves, cinnamon, allspice, ginger, and red pepper, dipped in vinegar or whiskey and placed over the affected region, is a very serviceable application, and not infrequently applied to the abdominal region.

Oil of turpentine is frequently used as a counter-irritant, the oil being soaked in flannel and applied to the part. Used in this way, it is a very active counter-irritant and must be watched.

Similar combinations, placed in small bags and applied to the gum over a tooth with inflamed root-membrane, are often effective as counter-irritants.

Capsicum (CAYENNE PEPPER) is the fruit of the *Capsicum fastigiatum.* The active principle is a liquid called *capsicin.* The dose of the powdered drug is gr. v–x.

PREPARATIONS:
- *Extractum capsici fluidum:* dose, ♏v–f℥j.
- *Tinctura capsici:* dose, ♏x–f℥j.
- *Oleoresin capsici:* dose, ♏j–v.
- *Emplastrum capsici.*

PHYSIOLOGICAL ACTION AND USES.—Capsicum is a local irritant of considerable energy. In small doses it stimulates the digestive secretion. It resembles ergot in its action on unstriped muscular fibre. It is employed as a stomachic tonic in ordinary dyspepsia, in the treatment of alcoholism, and in delirium tremens associated with insomnia. It is also used in malarial fever, in flatulent colic, and in cholera and choleraic disorders. The capsicum plaster is used for the relief of various muscular and neuralgic troubles, such as lumbago.

Dr. Kirk, who has had much experience in the use of capsicum in dental practice, contributes the following account of its mode of action: "I use capsicum as a local stimulant and counter-irritant in the initial stages of pericemental inflammation, and find it particularly valuable from the fact that it may be used continuously for any length of time necessary without producing vesication—a decided advantage in many cases over a more powerful counter-irritant or vesicant, as its continued gentleness of action apparently enables it to act through a greater depth of tissue without setting up, through the violence of its activity, an amount of local irritation equal to, if not greater than, that for the relief of which it is applied.

"Its value is most marked in the earliest stages of pericemental inflammation, before any formation of pus has taken place; in the later stages it is of little or doubtful value. In those cases of tenderness or soreness about the roots of pulpless teeth, whose pulp-chambers and canals have been rendered thoroughly aseptic and correctly filled, where the local inflammatory condition is due to some cause other than septic irritation—viz. external violence, 'taking cold,' etc.—capsicum as a local counter-irritant is the remedy *par excellence.* It fails ordinarily when the pericemental inflammation is caused by putrescent and septic

matter finding its way from the pulp-canals through the apical foramina and exerting its irritant action upon the pericementum. It may, however, be used as an adjuvant to thorough antiseptic treatment of the pulp-canals, and is useful in reducing the local inflammation afterward should it be inclined to persist. Its function when applied locally seems to be to exhaust the nervous irritability of a part by continued gentle counter-irritation of a grade short of that which induces vesication.

"I have found capsicum to be of great service as a local remedy for the relief of the severe neuralgias which not unfrequently follow extraction of lower molar and wisdom teeth. For this purpose a cataplasm about the size of the palm, made with capsicum one part and flour three parts, may be applied to the affected side of the face, or any of the so-called 'capsicum drafts' may be used for the same purpose. These have the advantage of being more elegant and cleanly, and are readily obtainable at first-class drug-stores. A satisfactory and reliable draft may be easily and quickly extemporized by thoroughly moistening a piece of heavy blotting-paper, about the size of the palm, with tincture of capsicum, and applying this to the cheek of the affected side. Relief generally follows the application at once.

"For the relief of pericemental inflammation recourse may be had to the 'pepper-bags' suggested by Dr. J. Foster Flagg, which consist of powdered capsicum sewed in small linen bags: these, when placed in the mouth over the region of the apex of the affected root, are very efficient and convenient. As they are somewhat bulky, and are likely, by reason of their convex surface, to become dislodged or to move about, I have substituted in my practice small oval disks cut from Seabury & Johnson's capsicum plaster, the surface of which has been lightly anointed with the ethereal extract or oleoresin of capsicum. These little disks, so prepared, are extremely useful; they are thin and flexible, by reason of which they adapt themselves nicely to the gum, and are extremely efficient."

EPISPASTICS.

Cantharis (CANTHARIDES), Spanish fly, is the dried beetle *Cantharis vesicatoria*. The active principle is *cantharidin*, $C_{10}H_{12}O_4$.

PREPARATIONS:
- *Tinctura cantharidis:* dose, ♏j–xxx.
- *Ceratum cantharidis.*
- *Ceratum extracti cantharidis.*
- *Charta cantharidis.*
- *Linamentum cantharidis.*
- *Emplastrum picis cum cantharidis.*
- *Collodium cum cantharidis.*

Cantharis applied locally is a slow but severe vesicant, the charta cantharidis being the most convenient form of application to produce a blister. Internally it is an irritant, causing nausea and vomiting, fever and scanty urine, which is often charged with blood and albumen.

The effect of blisters, whether produced by cantharis or by other means, is not well understood. They are believed to act by affecting the peripheral extremities of the nerves, supplying the part to which the agent

is applied, the irritation being transmitted to the nerve-centre, and this again radiating: they act primarily as a stimulant.

In dentistry *collodium cum cantharidis* is sometimes applied to the gum in cases of peridental inflammation. The lips and cheek must be carefully protected from its action until the blister has formed.

ESCHAROTICS.

To the second group of topical remedies, those which act on the tissues destructively or corrosively, belong *escharotics* or *caustics*, which are powerful chemical agents that destroy all forms of tissue with greater or less rapidity. In this group are included the following:

Heat, especially the galvano-cautery;
The mineral acids in concentrated form;
Zinc chloride;
The caustic alkalies in concentrated forms;
Arsenious oxide;
Acid nitrate of mercury.

These have already been described in connection with their other physiological effects. A few not otherwise classified remain to be noted here:

Bromum (BROMINE), Br., is a dark-red liquid evolving a very irritant and suffocating vapor; it is slightly soluble in water, more so in alcohol. It belongs to the chlorine group, and has in many respects the disinfectant and chemical qualities of chlorine. It is a very active and painful escharotic. Its vapor has been inhaled, much diluted with air, in acute inflammations of the respiratory passages, and it has been used in the concentrated form as an escharotic in chancre and hospital gangrene. The physiological properties of bromine internally administered are seen in the bromides, which have already been described.

Acidum Chromicum (CHROMIC ACID), CrO_3.—This substance, like the official white arsenic, is really an anhydride, the acid being formed only in the presence of water. It is, however, generally known as chromic acid. It forms deep-red, slightly deliquescent crystals. It is a powerful oxidizing agent, yielding its oxygen to many forms of organic matter. As an escharotic it is gradual in action and not very painful, for which reason in its use great care must be taken not to allow it to unconsciously penetrate too deeply. A solution of the strength of 100 grains to an ounce of distilled water is strongly recommended as a local application in syphilitic vegetations and in certain parasitic skin affections.

In dental practice chromic acid has been employed as an application to sensitive dentine. It is also of great service in the treatment of fungous growths of the gum and dental pulp. In the mouth it must be used with great care, in order to avoid injury to healthy tissue.

Abrus (JEQUIRITY) is the seed of the *Abrus precatorius*. It has not as yet been officially recognized. It is used in the form of infusion, three powdered seeds being macerated in half an ounce of cold water for twelve hours, and an equal quantity of boiling water added, the

infusion being filtered when cold. The active principle is not definitely ascertained. The solution must be used fresh. Its effects were at one time supposed to be due to the bacteria developed in the solution, but this is not now admitted.

Physiological Effects.—The infusion of jequirity is very poisonous, and has the special property when applied to the conjunctiva of causing a high grade of inflammation, extending to the adjacent organs.

Therapeutics.—It is used in the form of the infusion above mentioned for the purpose of destroying old granulations on the conjunctiva by producing a purulent inflammation. The infusion is applied to the eye two or three times a day, the applications followed by a weak solution of borax or alum.

There are as yet no uses of the drug special to dentistry.

Local Protective Agents.

A few substances are employed to protect the skin or mucous membrane from the irritant action of the air or from other influences. These are known as emollients and demulcents.

Glycerina (Glycerin), $C_3H_5(HO)_3$, was formerly included in this group, and is still regarded by many as an emollient; but it is not so. In many cases it is an irritant; and, being an alcohol in its chemical character, it is not to be expected that it should have much emollient quality. The fact of its having been obtained from fats, and that it is of a somewhat oily or fatty appearance, has probably led to a belief in its emollient character. It is a very active solvent, standing next to water in this respect.

Gossypium (Cotton).—Cotton fibre is the hair attached to the seed of the *Gossypium herbaceum*. The bark of the root is official, and also the fixed oil expressed from the seed.

Preparation:

Extractum gossypii radicis fluidum: dose, ♏xxx–f℥j.

Physiological Action and Uses.—Cotton-root is regarded popularly as stimulating uterine contraction, but this is doubtful. The oil from the seed has already been noticed. (See Oils and Fats.)

The fibre is well known for its textile uses, and in its natural condition contains adherent matters which prevent the free absorption of water; but by cleaning with alkaline solutions a readily absorbent fibre is obtained, known as *absorbent cotton.* This is the proper form to employ in the applications of cotton as a carrier or absorbent in dental practice.

By immersion in strong nitric acid cotton is converted into gun-cotton or pyroxylin.

Collodium (Collodion) is a solution of gun-cotton in a mixture of alcohol and ether. When applied to a surface the liquid evaporates, and a colorless, transparent, flexible contractile film of the gun-cotton is left on the surface.

Liquor Gutta-perchæ, the only official solution in which water is not used, consists of gutta-percha and chloroform. By the evaporation of chloroform the film of gutta-percha remains.

Several forms of skin affection are relieved by the use of these local agents.

The following are some other emollients which do not require more than mention:

Chrondrus (IRISH MOSS), the entire plant *Chrondrus crispus.*

Cetraria (ICELAND MOSS), from the *Cetraria Icelandica.*

Acacia (GUM ARABIC), from the *Acacia verek.*

Ulmus (SLIPPERY ELM), the inner bark of the *Ulmus fulva.*

Glycyrrhiza (LICORICE), the root of the *Glycyrrhiza glabra.*

Calendula (MARIGOLD), the herb of the *Calendula officinalis.* It contains a non-basic bitter principle, *calendulin.*

PREPARATION:
Tinctura calendulæ: dose, f℥j.

PHYSIOLOGICAL ACTION AND THERAPEUTICS.—Calendula is slightly stimulant and diaphoretic. In local application the tincture has been credited with a curative influence on contused and lacerated wounds, preventing inflammation and suppuration. There is, however, some doubt on this point.

It is used for the treatment of wounded and exposed tooth-pulps, and as an application after teeth-extraction; also in wounds of the mouth. A few drops of the tincture may be added to an ounce of water and used as a mouth-wash in inflammations.

ANTISEPTICS AND GERMICIDES.

The third group of topical remedies are those which are destructive to minute forms of organic life, whether animal or vegetable. Their principal application, however, is in the destruction of the exceedingly minute vegetable growths which are classed under the general term *microbes*, the specific forms of which are exceedingly numerous, and some of which are known to be connected closely with the development of general diseases or of local diseased processes in the system. The application, therefore, of agents destructive to these forms becomes of the greatest practical importance to both preventive medicine and therapeutics, more especially in view of the fact that recent investigations have shown that decay of the teeth is connected very intimately with the development of specific forms of microscopic life.

It appears, according to very recent researches, that in many cases in which microbes are developed, either in diseased tissues or under other favorable conditions, the excretions or the incidental products of the growth of these organisms are connected with the injurious influence that is produced. Many of these microbes develop in nutritive fluids bodies of marked physiological qualities, analogous to the alkaloids or

active principles upon which the medicinal virtues of plants depend. These are known as *ptomaïnes*. The processes of fermentation, of putrefaction, and of many other of the apparently spontaneous changes which organic matter undergoes are connected with the development of microbes. The agents, therefore, which prevent this development or which destroy the already existing microbes will in many cases prevent the changes that are dependent upon such growths; thus, the agents which destroy the microbes of putrefaction will prevent the decomposition of organic fluids; the agents which destroy the microbes of fermentation will prevent the fermenting process; and so on. Accordingly, we may make several subdivisions of this group, as follows:

ANTISEPTICS, those bodies which arrest the processes of putrefaction;

DISINFECTANTS, those which destroy infective matter;

DEODORANTS, a term which strictly applies to those bodies which absorb or destroy the odors that attend putrefaction or fermentation.

GERMICIDES (a term of the widest significance), including all substances which destroy any form of microbe or diseased germ.

It must be noted that there is an important difference between the mere suspension of the growth or functions of microbes and their destruction. Substances possessing the former quality only are not reliable as antiseptics or disinfectants, since they only temporarily interrupt the diseased process. The progress of investigation has not extended far enough yet to enable us to classify all the so-called germicide agents according to their true value, but in the descriptions of the different substances some idea may be given of their relative efficiency. A table giving a comparison of the effects of some of these agents will be found on page 808 of Vol. I. of this work.

Heat.—This, when its application is possible, is the most effective germicide agent. At the temperature of the boiling-point of water, 212° F., or even somewhat below, the greater number of forms of organic life, whether animal or vegetable, are killed. It appears from some recent observations of Dr. Sternburg that the temperature necessary for the destruction of the ordinary microbes is not so high as was formerly supposed; but it is also known that the spores or minute structures from which these germs develop and multiply are more difficult of destruction than the mature germ. Practically, it may be said that a temperature of 250° F. will be sufficient to destroy all microscopic life; and whenever such a process is practically applicable without being injurious to the object to be disinfected, it is the preferable method. In dental practice throwing a current of heated air into a putrescent pulp-canal (Register's system), or the repeated application of heated instruments to its surface, is a useful procedure. Since, however, heat is in many cases not available, and in a tooth cannot usually be safely made to act destructively upon the putrescent contents of the tubuli for their entire length, it is necessary to resort to other agents.

Chlorine, Cl.—This is a greenish-yellow gas, highly corrosive and irritant, a very powerful germicide; but, owing to the difficulty of using it practically, certain compounds in which it is in a loose state of com-

bination are preferred. Among these are *calx chlorata*, chlorinated lime or bleaching-powder, commonly but erroneously called the chloride of lime. The composition of this is not well made out. It consists largely, however, of calcium hypochlorite, $Ca(ClO)_2$, which is easily decomposed, yielding free chlorine. A more elegant preparation is made by decomposing this body by means of sodium carbonate, by which *liquor sodæ chloratæ*, solution of chlorinated soda, Labarraque's solution, is produced. This is substantially sodium hypochlorite, $NaClO$. A solution of chlorine in water under the name of *aqua chlori* is official, but it does not keep well. The above forms are efficient germicides and disinfectants. They are also deodorizers, as they have the power to decompose the gases which are emitted during fermentation and putrefaction. Experiments carefully conducted have shown that for general purposes of disinfection there is no more efficient agent than a well-made solution of chlorinated soda. It is comparatively harmless, and not very destructive to fabrics or household articles. It gives off but little odor.

In dental practice one of the chief uses of chlorine has been in bleaching discolored teeth, chlorinated lime being generally used for the purpose. (See p. 296, Vol. II.) The application, however, must not be too prolonged or too frequently repeated, or a considerable destruction of tooth-substance may result through the formation of hydrochloric acid. The difficulty of confining chlorine in a pulp-canal and of preventing its combinations with lime, soda, etc. from deteriorating, as well as its irritant properties and offensive smell, has prevented its general employment in the treatment of putrescent pulps, notwithstanding its high germicidal and disinfectant powers. To correct fetor of the breath, however, it may be employed to great advantage, the following formula by Bartholow making an effective preparation:

℞. Calcis chloratæ,	ʒiij ;	
Aquæ destillatæ,		
Alcoholis,	āā. f℥ij ;	
Olei rosæ,	grs. iv.	M.

S. Place a teaspoonful in a glass of water and use as a mouth-wash and gargle.

Iodine and **Bromine**, which belong to the same group as chlorine, are analogous to it in their action, but seem less powerful.

Acidum Salicylicum (Salicylic Acid), $HC_7H_5O_3$.—Salicylic acid forms white crystals, not very soluble in cold water, more freely in alcohol. It is one of the ingredients of the volatile oil of wintergreen. The sodium salt, *sodii salicylas*, is official. Both the acid and sodium salt are used internally in doses of from 5 grains to 30.

Physiological Action and Uses.—In small doses salicylic acid stimulates the digestion, circulation, and respiration, but very frequently disorders the stomach, causing nausea and vomiting, and in large doses lowers the arterial tension, relaxes the vessels, and reduces temperature. It also causes various disturbed actions of the cerebrum. Sodium salicylate agrees in the main with the therapeutic effects of the

acid, but is less irritating and may be given in larger quantity. In 15-grain doses, given several times a day, it lowers the temperature considerably; but it is believed not to have any antiseptic powers, unless the salicylic acid be set free by an acid. Salicylic acid and its salts are used chiefly in rheumatism to relieve pain, lower temperature, and reduce swelling. In many cases in the treatment of rheumatism with salicylic acid it will be found not to produce the expected effects, and should then be abandoned. Experiments have been recently made to show that doses of the acid short of the amount necessary to produce distinct physiological effect can be taken for a long time without apparent injury. This fact has an important bearing in view of the extensive use of this agent as a food-preservative. A considerable number of easily decomposed articles of food, such as milk, vegetable extracts, prepared meats, etc., are now preserved by the addition of salicylic acid.

Oleum Caryophylli (Oil of Cloves), $C_{10}H_{16}$.—The volatile oil of cloves is made up of a hydrocarbon of the same composition as oil of turpentine, and the oxygenated derivative from it called eugenol, or sometimes eugenic acid. It also contains some salicylic acid and a peculiar camphor.

Oil of cloves has been long known and used as a local application in affections of the teeth, particularly in the ordinary cases of toothache from exposed and inflamed pulp. The eugenol, being the active principle, is more effective than the oil itself. It has practically no poisonous qualities, and in a concentrated form coagulates albumen. Dr. A. W. Harlan has strongly recommended the use of eugenol, not only for relieving pain of exposed pulp, but as a dressing applied to the canals of recently exposed pulps, and for pyorrhœa alveolaris. In the latter affection it is used, one part to a thousand of water, for the purpose of cleansing out the pus-cavities. It has also been recommended in the treatment of alveolar abscess. Combinations of eugenol and iodoform are also efficient.

Oleum Thymi is the volatile oil obtained from the garden herb thyme. It contains a liquid hydrocarbon and a solid crystalline substance closely related to carbolic acid, commonly known as thymol. Thymol is now much in favor as a germicide and antiseptic. It can be administered in considerable doses. Ten grains a day internally for some time produce no alarming effects. Its antiseptic powers are quite positive, and are of the same general character as those of carbolic acid, but more energetic. It has lately been suggested as an internal remedy for typhoid fever for the purpose of destroying such of the germs of that disease as may be present in the intestines or even in the blood. In dental practice it has been used as a germicide in the treatment of putrescent pulps, and for that purpose may be dissolved in alcohol or glycerin. Thymol is only sparingly soluble in water, but dissolves in alcohol, ether, and oils.

Eucalyptol, a volatile oil derived from the *Eucalyptus globulus*, is also an antiseptic similar in effects and uses to the other members of this group

Acidum Carbolicum (CARBOLIC ACID), phenic acid, phenylic alcohol, phenol. The last term is preferable, but, owing to the widely-extended use of the term "carbolic acid," it will be freely used in this article. Carbolic acid is not an acid in the strict sense of the word, but is an alcohol or phenol hydroxide, its composition being C_6H_5HO. Phenol is obtained from coal-tar by distillation. This body must not be confounded with *creasote*, a product obtained from the distillation of wood-tar, and having somewhat similar properties. Both coagulate albumen, but creasote will not separate nitro-cellulose from its solution in collodion—a distinction which may serve as a test. Phenol when pure occurs in slender snow-white crystals of a smoky odor, which liquefy when mixed with a small quantity of water, but form a turbid solution with a large quantity, until the proportion reaches 1 part of acid to 20 of water, when the liquid becomes clear. The so-called "crude carbolic acid" of commerce is an unreliable preparation, often consisting largely of neutral tar-oils which are inert.

For dental purposes the best quality of phenol only should be employed. For general disinfectant use, an article containing about 94 per cent. of pure acid, under the name "carbolic acid No. 4," is suitable. Solutions of phenol as follows are used as antiseptic liquids: For spray or vapor, 5 per cent. in water; for sponges or lotion, $2\frac{1}{2}$ per cent. in water; and as a special dressing, 5 per cent. in olive oil. The dose internally of phenol is gr. $\frac{1}{4}$–j. Lister's solutions for antiseptic treatment are as follows:

1 to 40, 12 grs. to oz.
1 " 30, 10 " "
1 " 20, 24 " "

PREPARATIONS:

Unguentum acidi carbolici, strength, 10 per cent.

Sodii sulpho-carbolas, $C_6H_5NaSO_42H_2O$.

Phenol unites with sulphuric acid to form *acid phenyl sulphate*, commonly called sulpho-carbolic acid, $C_6H_5HSO_4$. This will form salts—for instance, sodium sulpho-carbolate, a crystalline body soluble in five times its weight of water. The sulpho-carbolates are much less poisonous than phenol itself, and hence are used as substitutes for it: dose, gr. x–xxx.

Phenol is capable of exchanging one of its hydrogen atoms for metallic elements, forming a class of compounds resembling salts, and from this analogy called the *phenates* or *carbolates*. Indeed, it is on account of the formation of these bodies that the term "carbolic acid" originated. Ordinary alcohol also shows this property thus by the action of metallic sodium on absolute alcohol, sodium ethylate, NaC_2H_5O. For the corresponding derivatives from phenol the term "phenylates" would be correct—thus, NaC_6H_5O, sodium phenylate—but they are generally styled as given above.

Sodii carbolas, sodium carbolate: dose, gr. v–x. This is a monosodium phenol, NaC_6H_5O, prepared by dissolving carbolic acid in caustic soda. It can be obtained in the crystalline form by treating carbolic acid with metallic sodium: dose, gr. v–x.

Phénol sodique (unofficial) is a solution of the sodium carbolate much used in dental practice. The following is the formula for its preparation:

Take of	Melted carbolic acid, pure,	5 parts;
	Solution of caustic soda, specific gravity 1.332,	1 part;
	Distilled water,	5 parts.

Mix.

Potassium phenate (unofficial) is prepared by rubbing together equal parts of carbolic acid and caustic potassa (Robinson). It is precisely analogous in composition to the monosodium phenate.

PHYSIOLOGICAL ACTION.—Carbolic acid coagulates albumen, and in

sufficient strength destroys the minute organisms which cause putrefactive and other fermentations. Its germicidal power is now known not to be so great as was at one time supposed, many other substances, especially chlorine, mercuric chloride, bromine, and iodine, excelling it in this respect. Applied to the skin, it causes burning pain, and immediately produces a superficial eschar of a white color, due to the coagulation of the albumen of the tissue: the parts also become locally anæsthetized. If the application is made in great volume and strength and is long continued, the destructive influence will involve all the subjacent tissues, death and "mummification," or gangrene, ensuing. It is stated by A. H. Allen that these local effects are much more destructive when they involve the lower half of the body. Upon mucous surfaces similar effects are produced, although saturated solutions can be applied to the gum-tissues with comparative immunity, owing, probably, to the neutralizing influence of the saliva. When swallowed it becomes a violent gastro-intestinal irritant, and if taken in considerable volume it, after a preliminary excitation, produces paralysis of the spinal cord, the medulla, and the respiratory and vaso-motor centres. The heart and lung movements, at first quickened, soon become depressed; the temperature is lower; there is impairment of sensory and motor power, followed by contraction of the pupil, suspended reflexes, stupor, collapse, and death. As small an amount as six grains has been known to produce dangerous effects, and almost immediately fatal results have followed the swallowing of a fluidounce of a strong solution. Applied too freely to cutaneous or mucous surfaces, it may be absorbed in such volume as to produce serious and even fatal consequences. This fact renders its use in antiseptic surgery dangerous, and is one of the reasons which has led to the substitution of other agents in this method of treatment. Carbolic acid is largely excreted by the kidneys, and causes the urine to assume a characteristic dark-brown color.

Antidotes.—As antidote to its poisonous action the official syrup of lime is employed; also magnesium sulphate or sodium sulphate. These latter form with phenol, sulpho-carbolates, thus losing much of their poisonous action. Vegetable demulcents may be used, but oils or glycerin should not be employed. Atropine is physiologically antagonistic.

Therapeutics.—Phenol was formerly in great favor as an antiseptic and germicide, and was among the first substances used in the modern methods of antiseptic surgery. It has, however, as already stated, now gone much out of favor, and by many has been abandoned altogether. It is not a very powerful germicide, except in concentrated solution; its odor is objectionable, it is irritant to the skin and other tissues, and capable of absorption in dangerous amount. Recently several more efficient and pleasant antiseptics of the phenol class have been introduced. Phenol is used in small doses ($\frac{1}{4}$ grain), for the relief of nausea and vomiting. Potassium, sodium, calcium, and sulpho-carbolates have been used in diseases due to or supposed to be due to germ development, as in diphtheria, scarlet fever, and a combination of iodine and carbolic acid has been employed in the treatment of typhoid fever. Locally, for nasal catarrh it is often an efficient remedy, and is best

administered in the form of spray from an atomizing apparatus, although the douche or syringe may be employed to introduce the fluid. A solution for this purpose should vary in strength from a grain to two or three grains of phenol to the ounce of water, the weaker solutions being first employed until some tolerance of the application. Inhalations of the vapor of pure carbolic acid in combination with tincture of iodine have also been used with advantage. Similar applications are also of service in hay asthma and chronic pulmonary affections. The parenchymatous injection of a 2 per cent. solution may be used to destroy the secreting power of serous membranes, as in the treatment of hydrocele, synovitis, enlarged bursa, etc. Parasitic skin diseases also are often benefited by it. As a mild escharotic it is of service in the treatment of many morbid growths, vegetations, unhealthy granulations, and suppurating and sloughing surfaces.

Uses in Dentistry.—Although not so extensively employed as formerly, carbolic acid still remains a useful and important remedy in dental practice. As an agent for allaying pain in an exposed dental pulp it has few superiors, and in hyperæmia, hypertrophy, chronic inflammation and structural degeneration and suppuration of that organ it is often of signal service in improving the morbid conditions. For these uses it can be applied in aqueous solutions varying in strength from 2 per cent. up to the highest possible saturations. By many, the superficial eschar which it produces when applied to the point of exposure is considered as an important factor in the successful conservative treatment of the pulp, this eschar being regarded as forming a protective film, beneath which the organ, stimulated to a healthier activity by the influence of the drug, will be enabled to perfect reparative processes and enter anew upon its career of usefulness. Others prefer in such cases very weak dilutions, and regard the quiescence which may follow the stronger application as an indication not of restored health, but of approaching dissolution. Many successes and a still larger number of failures have followed each method, and all methods, of practice, and our knowledge of the exact rationale of repair in such cases and of the rôle which these forms of medication really play in the process can hardly be said to rest, as yet, upon other than an empirical basis. As an obtundent for sensitive dentine pure carbolic acid or the potassium phenate or carbolate referred to above is often of service.

In the treatment of putrescent conditions of the pulp and its canals carbolic acid has largely given place to agents having higher germicidal power, such as mercuric chloride, iodine, and iodoform, and it is certain that much more successful results attend the employment of the latter agents.[1] As a stimulant and antiseptic application in alveolar abscess no single remedy is more successful than carbolic acid. For this use the deliquesced crystals should be employed, and if the entire surface of the sac and fistulous opening can be reached by the agent, full recovery is almost invariable, unless there be present necrosed bone or denuded and roughened roots.[2] In abscess of the antrum also, after the removal of mechanical sources of irritation, such as diseased roots,

[1] For a full discussion of this subject the reader is referred to Vol. I. p. 906 *et seq.*

[2] See Chronic Alveolar Abscess, Vol. I. p. 935.

necrosed bone, etc., injections of carbolic-acid solutions are of excellent service. As such injections must pass out the nasal cavity, they must of course be much weaker than for simple alveolar abscess, and a 2 per cent. solution is quite as strong as can be well tolerated, and at first even weaker dilutions must be employed. Such applications, in addition to mechanically cleansing the cavity, correct fetor and produce a stimulant and astringent effect upon its lining membrane. Dr. Litch recommends freely washing out the antrum with a solution of common salt about as strong as sea-water, as preliminary to the carbolic-acid injection. The secretions bathing the diseased surface are clotted and readily washed away by this application, leaving a cleaner surface for the action of the subsequent injection. The salt water can most conveniently be applied by means of a Davidson syringe to the smaller nozzle of which the still smaller silver nozzle of a dental syringe can be fitted. After charging the syringe, the point of this nozzle, which should be but slightly curved, should be placed in the fistulous opening in the mouth or on the cheek, and, without using undue force, a steady stream be thrown into the antrum until the fluids which escape into the nasal cavity are without odor. Simply filling the antrum with the carbolic-acid injection, introduced by any small syringe, will then suffice.

Carbolic acid in solution is often of service in various pathological states of the oral mucous membrane, such as stomatitis, thrush, aphthæ, etc., and it may be used as a styptic in hemorrhage following tooth-extraction. For this purpose the *phénol sodique* is very efficient. Through its action on the sensory nerves its local anæsthetic power is very great, hence its alleviating influence in toothache from pulp-exposure. Applied to gum-tissue about to be lanced or to the gingival margins in placing feruled crowns, sensation can be greatly diminished; often it is quite as efficacious in such cases as cocaine.

Creasotum (Creasote).—This is a constituent of wood-tar, and is a mixture of several bodies allied to phenol. It is an inflammable oily liquid, but slightly soluble in cold water (1 : 80), but freely soluble in alcohol, chloroform, and ether. It is distinguished from phenol by not coagulating collodion. Coal-tar oils and impure phenols are often sold as creasote, and being, even when properly prepared, of uncertain composition, it has gone very much out of use. A 1 per cent. solution in water, *aqua creasoti*, is official: dose, f℥j–ij.

Physiological Actions.—These are almost identical with those of carbolic acid, and its toxic effects are the same.

Therapeutics.—In general medicine it may be applied in many of the diseases for which phenol is now employed. Its greater local anæsthetic power makes it a more efficient remedy for the correction of nausea and vomiting reflex in origin, as in sea-sickness or that following general anæsthesia, and its use is now chiefly confined to this class of cases. The *aqua creasoti* is a good form of administration, as single-drop doses may be given mixed with bread-crumb in the form of a pill.

Dental Practice.—The unpleasant penetrating and persistent odor of creasote, and its want of solubility in water, taken together with the fact that in most cases it possesses no greater efficacy than carbolic acid,

and that in many cases it is inferior to it, have served to largely displace creasote from general use in dental practice. As a pain-obtundent in pulp-exposure it may be somewhat the more efficacious of the two agents, but it is doubtful if the difference is sufficiently great to counterbalance the disadvantages attending its employment. The fact that its own characteristic odor more effectually masks the presence of fetid emanations has led many to employ it as a deodorizer in pulp-putrefaction, but as the simple substitution of one odor for another is not a true antiseptic effect, its use for this purpose is not based upon sound therapeutic principles. Agents should be selected which destroy the causes of putrefaction, and the factor will then disappear.

Resorcin, $C_6H_4(HO)_2$, (unofficial).—Resorcin differs from phenol in the substitution of 1 molecule of HO (hydroxyl) for 1 atom of hydrogen. It is an artificial product. It forms colorless, odorless crystals neutral to test-paper, of sweet taste, soluble in water and also in alcohol. The dose is gr. x, which may be repeated every few hours, or ʒj, not repeated. Resorcin is but slightly irritating, and is less objectionable than phenol, and is equally powerful as an antiseptic. It does not cause inflammation or abscess when used hypodermically, but will vesicate mucous membrane. In doses of from 30 to 60 grains it causes profuse perspiration and languor, and if fever be present the temperature is reduced, but again rises. Large doses cause convulsions and tetanic rigidity. The symptoms of poisoning are similar to those of carbolic acid, and the physiological antagonistics are the same.

Acidum Boricum (Boric Acid), H_3BO_3, formerly called *boracic acid*, occurs in white shining crystals soluble in water and alcohol, and showing only weak acid properties, and but slightly irritant effects. It has come into prominence recently on account of its germicide qualities. Besides the acid, there is an official sodium compound called sodium borate (*sodii boras*), but really an anhydroborate, that is a combination of the acid anhydride, B_2O_3, with the true sodium borate. This compound, generally known as *borax*, has the composition $Na_2B_4O_7+10H_2O$. Various preparations of boric acid, such as ointment, solution, etc., are now used, but are not yet official. One of the best of these is *boroglyceride*, a solid substance, made by mixing 62 parts of boric acid and 92 parts of glycerin, and heating the mixture until 34 parts are driven off. It is soluble in both water and glycerin, and readily mixes with carbolic acid. It possesses in a high degree antiseptic and germicide qualities, and appears to be not poisonous. It is generally used in solution (1 : 40).

Potassium boro-tartrate, analogous in composition to potassium antimony tartrate (tartar emetic), is made by heating boric acid, cream of tartar, and water. It is used as a solvent for uric acid calculi.

Sodii boras, sodium anhydroborate, borax, $Na_2B_2O_4,B_2O_3+10H_2O$, is colorless, crystalline, slightly alkaline, soluble in water, but not in alcohol. It possesses properties analogous to those of boric acid. It has a slight local action on the skin.

Mel sodii boratis, borax 60 grains; honey, 1 troyounce.

Physiological Action.—Boric acid and its compounds are chiefly remarkable for their antiseptic and germicide properties, and their action as internal remedies has not attracted much attention. Fatal cases of poisoning from its too free use as an antiseptic have been reported. The principal symptoms were marked vomiting, flushed skin, slight rise in temperature, followed by motor paralysis. Boric acid will arrest fermentation and putrefaction.

Therapeutics.—Boric acid has been used internally for the relief of vomiting, and also in septicæmia. Its principal use, however, is as a preservative in various organic solutions, and as a dressing in surgical cases and in purulent inflammations. In these latter cases it is used in the form of impalpable powder. A solution of 1 part in 130 arrests the activity of bacteria. Boric acid is also used as a local application in ulcers, burns, and parasitic skin affections. In aphthous and other ulcerations of the mouth and fauces, fissured tongue, abrasions produced by wearing artificial plates, etc. it is very efficient. A solution of about twenty grains to the ounce, of water, glycerin, or honey, may be used. A good formula is that of Dr. C. N. Peirce:

Boric acid,	grs. lxiv;
Oil of wintergreen,	f℈ss;
Glycerin,	fʒiv;
Alcohol,	f℥j.

Water enough to make four ounces.

Naphthalene, $C_{10}H_8$, is obtained from coal-tar. It forms white shining crystals of strong, slightly disagreeable odor, insoluble in water, but soluble in alcohol. It is germicidal in its action, and internally it is stimulant. It has been employed as a local application to indolent ulcers and as a disinfectant to pus-cavities and open wounds. It has also been largely used in the treatment of skin affections. Other antiseptics of more agreeable odor and equal or greater efficiency take precedence of it in dentistry.

Naphthol, $C_{10}H_7HO$.—This is an alcohol derived indirectly from naphthalene by substitution of 1 atom of H by a molecule of HO. Two forms are known, however, called respectively α and β naphthol. β naphthol is the form now used, being much less irritating and injurious than the α form.

β naphthol forms light brownish crystals soluble in hot water. It has been highly spoken of as an antiseptic, and appears to be safe for use both locally and internally. It has proved efficacious in the treatment of parasitic diseases of the skin—such as scabies—and is serviceable for general local use as an antiseptic.

In dentistry it could be used in the same formulæ as given for other germicides.

Hydronaphthol occurs in light fawn-colored crystalline flakes having a slight odor and taste. The chemistry of it is not well made out; it is probably a form of β naphthol: it certainly bears a close resemblance

to it. It does not appear to have the power to destroy already existing germs or their spores, but to possess merely an inhibitory action on their development. Dr. James Truman recommends a solution of 1 : 1000 of water for injection into the pulp-canals of pulpless teeth. Dr. E. C. Kirk furnishes the following: "In addition to its antiseptic property it possesses slight stimulant and counter-irritant qualities, similar in character to, but probably in a less degree than, capsicum. Made into a paste with glycerin and pumped into a thoroughly cleansed pulp-canal, it has afforded me most gratifying results in the treatment of pericemental inflammation which had an undoubted septic origin, the soreness and inflammation disappearing completely in a few hours. The application may be sealed in with gutta-percha at once, without fear of subsequent trouble. It is most efficacious in the early stages of pericementitis before pus has formed."

Iodoformum (Iodoform), CHI_3.—This body is analogous to chloroform, iodine being substituted for the chlorine. It is, however, very different in physical properties, being a bright yellow crystalline solid of a penetrating odor, to most persons highly disagreeable. It is insoluble in water, but soluble in alcohol, chloroform, ether, fixed and volatile oils.

Physiological Action and Uses.—It has no irritant action, and in small doses has the alterative properties of the iodine compounds. Its principal use is its local application, it being considered one of the most reliable and efficient antiseptics. It is now very largely used in the dressing of wounds and in surgical operations.

In dental practice it is not infrequently combined with eucalyptus. It is not likely to act as an escharotic. Dr. Pierce recommends a mixture of equal parts of oil of cloves and oil of eucalyptus, with sufficient iodoform to form a soft mass. This mixture can then be applied to inflamed structures. A solution of iodoform in collodion has also been recommended. Iodoform is also used in alveolar pyorrhœa, being packed into the pus-pockets. It may be combined in any of these applications either with the remedies just mentioned or with eugenol or thymol. Various expedients have been resorted to to disguise the odor—small amounts of essence of rose, oil of cinnamon, oil of lavender, the active principle of the tonka bean, or the essence of rose geranium. Some surgeons believe that iodoform is best used in the crystalline condition, but for dental practice it has been found that the fine powder is most suitable. It is sometimes employed directly for relieving the pain of exposed pulps or that following extraction of teeth.

The following are some of the formulæ for combinations of iodoform in dental practice:

For Putrid Pulps:

Iodoform, $\frac{1}{25}$ grain;
Camphor, 15 grains;
Alcohol, 1 ounce.

Dissolve the camphor in the alcohol, add the iodoform.

For Odontalgia:

Powdered iodoform,	60	grains;
Kaolin,	60	"
Carbolic acid,	8	"
Oil of peppermint,	10	drops.
Glycerin to form a thick paste.		

Apply directly to the pulp.

Omitting the glycerin and peppermint oil, the same formula may be used as a capping in pulpitis.

Dr. Kirk communicates the following: "In using iodoform as a canal-dressing, I make it into a paste with cinnamon oil, which disguises the offensive odor entirely. The paste so made I find useful in the treatment of devitalized teeth in which there is a tendency to recurrent inflammatory action of a subacute type, which keeps up a slight but continued soreness that will neither improve nor grow worse. In these cases I find the iodoform paste a reliable sedative, mild in its action, but of great persistency."

Iodol (TETRAIODOPYRROL), C_4HNI_4.—This body has lately been brought prominently into notice as an efficient germicide without toxic properties and free from the objectionable odor and taste of iodoform, with the effects and uses of which it closely agrees: dose, internally, gr. iv. Iodol is nearly insoluble in water, 1 to 5000 parts, but very soluble in absolute alcohol; also in ether, chloroform, and carbolic acid. The alcoholic solution is precipitated by water, but it may be mixed with an equal part of glycerin without change. Iodol is also soluble in olive oil and in various alkaline solutions. It may also be employed in a state of fine powder with ointments or vaseline. It contains 90 per cent. of iodine.

PHYSIOLOGICAL ACTIONS AND USES.—These are substantially those of iodoform, which, it is believed, it will replace on account of its freedom from disagreeable odor. It has a slight caustic action. No poisonous effects have been noticed even when the drug was long continued.

The following are some of the formulæ advised:

Take of Iodol,	1	part;
Alcohol,	16	parts;
Glycerin,	34	"

For use locally with a brush or by spray.

Take of Iodol,	1	part;
Ether,	8	parts.

This is a quickly-evaporating application.

Iodol obviously may be substituted for iodoform in the various formulæ in which that agent is included, the iodol being used in rather larger amount.

Hydrogen Dioxide, H_2O_2.—This body, discovered many years ago by a French chemist, long remained a chemical curiosity, although its peculiar and striking properties were recognized by its discoverer. It

is produced by oxidizing water by means of freshly-liberated (nascent) oxygen. The usual process consists in decomposing barium dioxide by sulphuric acid in the presence of considerable water, the mixture being carefully kept cool. The solution so prepared is comparatively dilute. It may be concentrated by careful management, and in the pure form hydrogen dioxide is a syrupy liquid easily decomposed, decidedly caustic, and acting powerfully upon various organic and inorganic materials. The dilute solution keeps tolerably well. Hydrogen dioxide is soluble in ether, and this solution keeps better than that in water.

Physiological Action and Uses.—Hydrogen dioxide has come into use recently for the treatment of local purulent inflammations, particularly in the ear and mouth. It is, for instance, employed with much success in the treatment of such inflammations of the middle ear. When brought in contact with pus the dioxide is decomposed, oxygen being set free, which escape causes a frothing of the fluid; and this is an index to its action. Its application may be made in small quantities until the cessation of the frothing indicates that the pus has been destroyed. Dr. Burnett recommends it very highly in the treatment of purulent affections of the middle ear, but regards its useful effect in such cases as limited to the destruction of pus.

Dr. A. W. Harlan has recently strongly advocated the use of this remedy in the treatment of alveolar pyorrhœa, and gives the following method of employment: "The aqueous solution is used in the treatment of plain alveolar abscesses and alveolar pyorrhœa. As the rapid evolution of the oxygen effects a thorough evacuation of the pus, one may see the thin frothy contents of a non-fistulous abscess, even though the teeth are in the lower maxilla, gradually escape from the sac beneath if the agent be thoroughly applied. In practice, after opening the canal, I at first very gently wash out the canal from whence the pus is oozing, and after carefully injecting the remedy into the sac, which is immediately distended by the evolution of the oxygen and the complete evacuation of its contents, I then introduce cotton saturated with eucalyptus oil and lightly seal the cavity. The dressing is to be changed in three days, when, if there be no pus or odor, the canal is to be packed tightly with cotton moistened as before and sealed with gutta-percha. In a week or ten days the root may be filled, leaving the cavity of decay to be filled when convenient. In some cases it may be necessary to repeat the application. The rubber dam must always be adjusted over the tooth while treating it or changing the dressing. I prefer eucalyptus oil as an after-dressing, because of its not being escharotic or irritating."

Dr. Harlan has also strongly advised the following method: "First pack the pus-pockets with iodoform and eucalyptus oil, or thoroughly syringe with a one- to three-grain solution of aluminum chloride to the ounce of water, which will relieve the suffering and reduce the swelling of the gums after three or four days. The deposits may be removed and the edges of the alveoli burred off. The pockets are then syringed with the hydrogen dioxide, and after drying injected with a few drops of a solution of zinc iodide, twelve grains to the ounce of water. On the fourth day the gums are carefully dried, and a fine piece of cotton or bibulous paper moistened with hydrogen dioxide is pressed into each

pocket. If effervescence occurs, it denotes the presence of pus, and each pocket should again be injected with the zinc iodide."

The original use of hydrogen dioxide was for bleaching the hair, and it is not unlikely that it will answer for bleaching the teeth. It is a powerful germicide.

Mercuric Chloride (BICHLORIDE OF MERCURY, CORROSIVE SUBLIMATE, $HgCl_2$).—This is one of the most powerful germicides known. It is now very extensively used in antiseptic surgery. It is commonly employed in solution in water, 1 part to 2000 (approximately, 1 grain to 4½ ounces of water). Stronger solutions are sometimes used on the unbroken skin. In all uses of mercuric chloride it must not be forgotten that it is a powerful poison and in solutions of moderate strength will corrode metallic instruments.

A combination of mercuric chloride and hydrogen dioxide is recommended by Dr. Black, as follows:

Hydrogen dioxide, f℥j;
Mercuric chloride, gr. ij.

For use as an injection in alveolar abscess and into pockets under gum in phagedenic pericementitis. The treatment should generally be repeated at each sitting for the purpose of freeing the pockets from all decaying matter before the application of other remedies.

Various combinations of mercuric chloride and soap have been extensively advertised, but these are all valueless. All metallic disinfectants are incompatible with soaps, since they precipitate the acids of the soap in an insoluble form. The only combinations that are allowable with soap are the organic germicides, such as thymol, naphthol, etc.

DENTIFRICES.

Under this term may be included all local applications for the preservation of the teeth. A very large number of formulæ have been proposed for this purpose. The majority of them are constructed upon the principle of providing a fine insoluble powder to act as a mechanical agent in removing salivary incrustations, and flavoring materials to impart pleasant odor. In view of the recent progress, however, in the study of dental caries, and the intimate relation that is known to exist between microscopic life and the diseases of tooth-structure, it appears that the true dentifrices should be constructed upon a germicide basis. It is, however, not possible to employ any of the powerful or chemical germicides, as this would produce decided injury to the tooth-structure, and cause local inflammations that would be very objectionable. Some of the comparatively non-irritating but active organic germicides or weak organic acids are alone suitable for dentifrices. It does not seem reasonable to suppose (in spite of the general leaning of the profession in this direction) that the use of any of the insoluble vegetable powders, such as orris-root or cinchona-bark, is advisable. These substances are wholly insoluble and very slow in decay, and minute spiculæ of them may remain for a long time in the recesses of the gums and teeth to

promote germ-development. Miller of Berlin, however, has recently furnished the following formulæ:

No. 1. Ordinary Dentifrice.

Precipitated calcium carbonate	$3\frac{3}{4}$ oz.
Cinchona-bark	15 drachms.
Prepared oyster-shell	15 "
Powdered myrrh	$7\frac{1}{2}$ "
Powdered cloves	$3\frac{3}{4}$ "
Oil of cinnamon	10 to 15 drops.

Mix well.

No. 2. Antiseptic and Germicide Mouth-wash.

Thymol	4 grains.
Benzoic acid	45 "
Eucalyptol	$3\frac{1}{2}$ drachms.
Alcohol	25 "
Oil of wintergreen	25 drops.

Mix.

A teaspoonful of this mixture, put into a glass of water, and the mouth rinsed with the liquid after each meal and upon going to bed.

The second formula appears to be a satisfactory basis for the construction of a scientific dentifrice. There seems to be no reason for the use of the complex insoluble mixture such as constitutes No. 1, since the end in view could probably be reached by an association of magnesium carbonate, which is a smooth and not very insoluble powder, with germicides referred to in the second formula. As thymol may be given internally in ten-grain doses without unfavorable results, it might advantageously be combined with magnesium carbonate and sufficient of some fragrant oil, such as oil of cloves or cinnamon, to make a pleasant mixture; and this would constitute an antiseptic dentifrice. Formerly, wood-charcoal was used in these mixtures, but it is certainly highly objectionable, as it is an entirely insoluble powder, and in the form in which it was employed it either has no absorbent or preservative qualities, or has lost them by immersion in the fluids of the mouth.

By the employment of combinations of the different antiseptic and astringent remedies with insoluble powders a large number of dentifrices and mouth-washes may be prepared. The preference for any form will be a matter, in the main, of individual taste, the correct principle being to keep to the simplest formulæ. The complex dentifrices so often recommended are objectionable.

Disinfectant and Antiseptic Lotions for the Mouth.

In addition to Dr. Miller's formulæ, given above, the following are recommended:

Thymol,	gr. xx;
Glycerin,	
Alcohol, each,	f℥j;
Distilled water,	Oj.

Sol. chlorinated soda,	f℥iij;
Water,	f℥iij.

The above formulæ will probably be found to fulfil every indication. The ingredients of the two should not be combined, and in general it may be said that the inorganic disinfectants should be used alone. The so-called chlorinated lime, *calx chlorata*, is analogous to the sodium compound above given, but is not so stable and is more irritating. Its use, however, has been suggested, and one formula may be given:

Chlorinated lime, ʒss;
Mucilage, f℥ss;
Water, f℥iij.

Chlorine-water has also been suggested, but it does not keep well. The following may be tried:

Chlorine-water, f℥ss;
Distilled water, f℥iv;
Syrup, f℥ss.

Dilute solution of hydrogen dioxide will probably be much preferable.

The newly-introduced "sanitas oil" (see p. 763), either alone or with small amounts of eugenol (sanitas 3 parts, eugenol 1 part), will be found available as an antiseptic mouth-wash. Quinine and chloral have antiseptic properties, and may also be used.

Astringent Mouth-washes.—Numerous formulæ for these have been published; it will be sufficient to select a few:

Powdered nutgall,
" Peruvian bark, each, ʒij;
" orris root, ʒj;
Infusion of rose-leaves, f℥iv.

Let the infusion stand for a day or so on the powders, occasionally stirring; decant and filter.

For soreness and ulceration of the gums the following is recommended:

Borax, grs. 40;
Honey, f℥j;
Sage tea, f℥iv.

This is a favorite domestic remedy.

The following is strongly astringent, and after using it the mouth must be rinsed well with water:

Alum, ʒij;
Decoction of Peruvian bark, f℥ij;
Infusion of rose-leaves, f℥ij.

Warm solutions of salt and decoction of various astringent barks are also available as mouth-washes. Potassium chlorate was at one time much used, but is gradually losing favor. If used, it should be prescribed with plenty of water—not less than one pint of water to the ounce of chlorate. It should not be mixed with any strong acid. It does not give up its oxygen at ordinary temperatures to organic matters, and is of no use as an oxidizing agent physiologically. (See also Potassium Permanganate, Arnica, Calendula, and Tannic Acid.)

ANTIPYRETICS.

The progress of organic chemistry has added to the list of remedies a large number of substances analogous to the active principles of plants, but entirely artificial. Among them are several bodies which have marked power of depressing temperature, and are known as antipyretics. A brief description of the more important of these will be given.

Antipyrine, $C_{20}H_{18}N_4O_2$.—This body forms colorless crystals soluble in water and having a rather sweet taste. It stimulates and then paralyzes the nerve-centres. It dilates the cutaneous vessels, and so increases loss of heat by radiation. The reduction of temperature takes place quickly. The dose is from 7 grains up to as high as 30, until 90 grains have been taken. It, however, sometimes induces dangerous symptoms—profuse sweating, feeble pulse, and collapse. Its powerful antipyretic action is utilized in typhoid fever, phthisis, and somewhat in pleurisy and pneumonia. The exact manner in which it acts is doubtful. It has some antiseptic power.

Antifebrin, C_2H_3NO.—This forms colorless plates somewhat resembling boric acid. It has a slight burning taste and is not very soluble in water. It reduces the temperature and pulse-rate. It is said to be much more powerful than antipyrine, and not to be so liable to produce dangerous symptoms. It may be used in much smaller doses than some of the other antipyretics, three or four grains being sufficient.

Thalline, $C_{10}H_{14}O$.—Thalline forms large colorless, bitter crystals, sparingly soluble in water, readily in alcohol. The commercial form is generally the sulphate. It is supposed to act by reducing the oxidizing power of the blood-corpuscles, and also acts by increasing the activity of the skin. It usually causes profuse sweating, and is apt also to cause great depression. It is best given in doses of about three grains. It is considered applicable in all fevers.

Kairine is seen in commerce in the form of a hydrochlorate, $C_{10}H_{13}NO,HCl + H_2O$. It is a grayish powder having a faint odor like phenol. It is supposed to reduce temperature by controlling the chemical action which takes place in the body; that is, by controlling tissue-change. It reduces the pulse and produces copious perspiration. The temperature may be reduced one-half to two degrees within twenty minutes after a full dose. Its action, however, is somewhat uncertain, and may be dangerous. The dose is four grains, cautiously increased slightly and then decreased.

Quinoline, C_6H_5N, is a colorless volatile liquid of a pungent odor, sparingly soluble in water, readily in alcohol. It is a powerful antiseptic and antipyretic, and is applicable to all febrile affections. It is apt to produce irritation of the stomach and collapse. The dose is from seven to ten grains, usually in the form of a tartrate.

At the recent meeting of the Association of American Physicians the subject of the use of these antipyretics was freely discussed. The general opinion was that antifebrin is about the safest and most effective antipyretic, but that none of them have the value which attaches to the cold bath as generally used. Dr. Whittaker of Cincinnati advocated the view that the bodies act by a germicide power, and not by a special action on temperature production.

PART VI.

DENTAL METALLURGY.

DENTAL METALLURGY.

By EDWARD C. KIRK, D. D. S.

METALLURGY, or the art of working metals, comprehends the whole process of separating them in the metallic state from the various other matters with which they are found naturally associated in the ore. In a more limited sense, metallurgy may be defined as the operation of obtaining metals from their ores.

A metal may be defined as a substance solid at ordinary temperatures, insoluble in water, and which is a good conductor of heat and electricity, and has a peculiar characteristic lustre both in mass and in powder called the metallic lustre. To this may be added the power which metals have of replacing hydrogen in its combinations; as, for example, when hydrogen sulphate or sulphuric acid is acted upon by iron the iron replaces its hydrogen, which is set free, thus:

$$H_2SO_4 + Fe = FeSo_4 + H_2.$$

Still another property characteristic of the metals is that their binary compounds with oxygen or oxides are, as a rule, basic, with the exception of arsenic, an element the true metallic character of which is in doubt, it being regarded by many as a connecting link between the metallic and non-metallic elements.

The term elementary body or element is applied to matter in its simplest condition—*i. e.* matter which physical or chemical processes have failed to break up or decompose into more than one kind of matter. The ancients applied the term "element" in an arbitrary sense to air, fire, water, and earth, but as now used it signifies matter that is not capable of further decomposition into two or more dissimilar kinds of matter.

Of the sixty-six elementary bodies at present known to us, fifty-two are metallic. They are as follows:

Names.	Symbols.	Atomic Weights.
Aluminum	Al	27.4
Antimony	Sb (Stibium)	120.
Arsenic	As	75.
Barium	Ba	136.8
Bismuth	Bi	207.
Cadmium	Cd	111.8
Cæsium	Cs	132.6
Calcium	Ca	40.
Cerium	Ce	140.4
Chromium	Cr	52.

Names.	Symbols.	Atomic Weights.
Cobalt	Co	58.9
Copper	Cu (Cuprum)	63.2
Davyum	Da	(?)
Didymium	D	145.4
Erbium	E	166.
Gallium	Ga	70.
Glucinum	Be (Beryllium)	9.
Gold	Au (Aurum)	196.2
Indium	In	113.4
Iridium	Ir	192.7
Iron	Fe (Ferrum)	56.
Lanthanum	La	138.5
Lead	Pb (Plumbum)	206.5
Lithium	Li	7.
Magnesium	Mg	24.
Manganese	Mn	54.
Mercury	Hg (Hydrargyrum)	199.7
Molybdenum	Mo	95.5
Nickel	Ni	58.
Niobium	Nb	94.
Osmium	Os	198.5
Palladium	Pd	105.7
Platinum	Pt	194.4
Potassium	K (Kalium)	39.
Rhodium	Rh	104.
Rubidium	Rb	85.3
Ruthenium	Ru	104.2
Silver	Ag (Argentum)	107.7
Sodium	Na (Natrium)	23.
Strontium	Sr	87.4
Tantalum	Ta	182.
Thallium	Tl	203.7
Terbium	Ter	148.5
Thorium	Th	233.4
Tin	Sn (Stannum)	117.7
Titanium	Ti	49.8
Tungsten	W (Wolframium)	183.6
Uranium	U	239.8
Vanadium	V	51.3
Yttrium	Y	89.8
Zinc	Zn	65.
Zirconium	Zr	89.4

The following-named elements are not included, as their identity has not yet been thoroughly established; should this be done, the number will be increased to seventy-six:

Decipium,	symbol	Dp	At. wt.	160	Neptunium,	symbol	Np	At. wt.	118
Holmium,	"	Ho	"	162	Philipium,	"	Pp	"	74
Ilmenium,	"	Il	"	105	Scandium,	"	Sc	"	44
Lavoisium,	"	Lv	"	?	Thulium,	"	Tm	"	170
Mosandrium,	"	Ms	"	?	Ytterbium	"	Yb	"	173?

But comparatively few of the metals were known to the ancients, probably not over seven, although those now in most general requisition, and to which the term "useful metals" directly applies, were familiar to them. The others are of comparatively recent discovery, and are the result of the more elaborate and accurate methods of chemical and metallurgical research of modern times, by which many substances previously regarded as elementary bodies, such as the hydrates of the alkali metals sodium and potassium, together with the

alkaline earths, were shown to be compound and their component elements isolated.

Metals have been worked from periods coeval with the earliest historical records, and evidences of metallurgical operations of considerable magnitude have been discovered, showing that these processes, though of the crudest character, were carried on at a period even more remote, and long before the knowledge of chemical science was sufficiently advanced to shed any light upon the principles involved in the work.

Metals are found in nature in the free metallic state or combined with one or more non-metallic elements: they are never found in a state of absolute purity, even those which occur native in an obvious metallic condition being more or less contaminated with other metals. By far the greater number are found in combination with the non-metallic elements as oxides, sulphides, etc.; this circumstance gives rise to an important division of the metals into two classes based upon their relative tendency to combine with the non-metallic elements—viz. the "noble" metals, or those which show little or no tendency to so combine, and the "base" metals, or those which readily enter into combinations with the non-metallic elements. The oxygen compounds of the noble metals are all decomposable by a temperature not exceeding redness, while the corresponding compounds of the base metals are not decomposable by heat alone.

The noble metals are as follows:

Mercury,	Gold, Silver,	Platinum,
Palladium,	Rhodium,	Ruthenium,
Osmium,	Iridium,	Davyum.

The base metals are sometimes classified according to certain other chemical and physical properties—viz. their behavior toward oxygen, the temperature at which they fuse or become fluid, etc.

Certain of the metals combine with oxygen, and the resulting compound or oxide is strongly basic; to this class belong zinc, cadmium, lead, and uranium. The oxygen compounds of others, such as copper, cobalt, nickel, tin, iron, manganese, bismuth, and antimony, may act either as acids or bases, while the oxides of arsenic always act the part of an acid.

The relative fusibility of the metals affords another means of classification, which for many purposes is sufficiently satisfactory. All metals may be fused, and the greater number volatilized, by heat, but as they melt at widely different temperatures, this difference may be utilized frequently as a means of distinguishing them. Thus, mercury is fluid at all ordinary temperatures, and only becomes solid at $-40°$; sodium and potassium fuse below the boiling-point of water; zinc, cadmium, lead, bismuth, and antimony become fluid below a red heat; cobalt, nickel, iron, and manganese only fuse at the highest furnace heat; while chromium and the platinum group of metals are only fusible by the oxyhydrogen blowpipe or by a powerful voltaic current. The relative fusibility of the more important metals is shown in the following table:

		Fahrenheit.	Centigrade.
Fusible below redness.	Mercury	—39°	—39.44°
	Potassium	143.6	62.
	Sodium	203.8	95.6
	Tin	442.	227.8
	Bismuth	507.	264.
	Lead	619.	326.
	Arsenic sublimes without fusion at	356.	180.
	Zinc	773.	412.
	Antimony	842.	450.
	Cadmium	442.	227.8
Red heat.	Silver	1873.	1023.
	Copper	1996.	1091.
	Gold	2016.	1102.
Highest forge heat.	Cobalt, rather less than cast iron.		
	Iron (cast)	2786.	1530.
	Iron (pure)	2912.	1600.
	Manganese.		
	Iron (malleable).		
	Nickel.		
Agglomerate, but do not melt in forge.	Palladium.		
	Molybdenum.		
	Uranium.		
	Tungsten.		
	Chromium.		
Fusible only in oxy-hydrogen blow-pipe.	Titanium.		
	Cerium.		
	Osmium.		
	Iridium.		
	Rhodium.		
	Platinum.		
	Columbium.		
	Tantalum.		

Specific Heat.—The capacity of different metals for absorbing heat varies with each metal. If the amount of heat required to raise a given weight of water through one degree Centigrade be taken as a unit of measurement, the amount of heat necessary to raise an equal weight of any metal through the same degree of temperature is called its specific heat.

The quantity of heat required to raise the temperature of a pound of water one degree Centigrade is adopted as the thermal unit, and the specific heat of any other body is the relative amount of heat necessary to raise a pound of that body one degree Centigrade, using the above thermal unit as a standard. The specific heats of the following metals are expressed in terms of that standard:

Mercury	0.03332	Nickel	0.1086
Gold	0.03244	Cobalt	0.1070
Silver	0.0570	Iron	0.1123
Zinc	0.0955	Lead	0.0314
Cadmium	0.0567	Palladium	0.0593
Copper	0.0952	Antimony	0.0508
Tin	0.0562	Bismuth	0.0308
Platinum	0.0311		

It has been found that a very simple relation exists between the atomic weights of the elements and their specific heats. This relation was shown by Dulong and Petit in 1819 to be an *inverse proportion of the atomic weights to the specific heats;* and the law thus discovered has furnished an accurate means for determining the atomic weights of

elements or of correcting errors in those previously determined by other methods.

The relative specific heats of several metals may be readily demonstrated in a rough way by superimposing a number of thin sheets of wax, each being separated a trifle from the others by means of small strips of wood, and dropping simultaneously upon the surface of the uppermost one several bullets of different metals which have been cast in the same mould and previously exposed for a time to the same source of heat; as, for instance, in a vessel of boiling linseed oil. It will be found that the number of sheets of wax perforated will vary considerably according to the metal, the one having the highest specific heat of course passing through the greatest number.

Expansibility.—Within certain limits, metals expand uniformly in direct proportion to the increase in temperature, but the rate of expansion varies with different metals. The following table shows the relative increase in length of a bar of the metals named at 100 degrees Centigrade whose length at 0° C. is 1.000000:

Platinum	1.00091085	Copper	1.00179673
Palladium	1.00100000	Silver	1.00200183
Antimony	1.00108300	Tin	1.00235840
Wrought iron	1.00124860	Lead	1.00285768
Steel	1.00121286	Zinc	1.00297650
Gold	1.00149824	Bismuth	1.00139200

The high rate of expansibility of zinc renders it particularly valuable as a metal for dies upon which to form plates for the mouth in many cases. The metal is cast while fluid and at its extreme limit of expansion, which upon cooling returns to its minimum dimensions, and thus furnishes a cast a little smaller than the plaster model which it represents. It has been found that this contraction of the zinc die a trifle more than compensates for the expansion which takes place in the plaster model in setting, and in the majority of cases a plate made thereon adapts itself more accurately to the mouth than one made upon a die of a less expansible metal. Even if the contraction undergone by the zinc is so great as to produce a die somewhat smaller than the mouth, so far from being a detriment, it is a positive advantage in most cases of full upper replacement, as under such conditions the pressure of the finished plate is greater upon the alveolar ridge than upon the central portions of the hard palate—a state of affairs the advantages of which are sufficiently obvious without explanation.

Conductivity.—The conducting power of metals for both heat and electricity is variable, though the metals are the best conductors of heat among the solid bodies. The following table shows approximately the relative conductivity of a few of the metals as determined by Matthiessen:

For heat.		For electricity, at 0° C.	
Silver	100.	Silver	100.
Copper	73.6	Copper	99.95
Gold	53.2	Gold	77.96
Tin	14.5	Iron	16.81
Iron	11.9	Tin	12.36
Lead	8.5	Lead	8.32
Platinum	8.4	Platinum	18.80
Bismuth	1.8	Bismuth	1.24

It will be observed that metals conduct heat and electricity in nearly the same ratio. The electrical conductivity is greatly diminished by heat and by alloying.

Malleability, Ductility, and *Tenacity* are properties which the metals possess by virtue of the cohesive power of their molecules. Malleability is the property which admits of their being extended by the hammer; ductility, of their being drawn into wire; and tenacity, the power to resist tensile strain, and is measured by the number of pounds' weight a wire or rod of given dimensions will sustain without rupture. The tensile resistance of a bar of metal increases in direct proportion to any increase in the area of its section.

These properties are shown relatively for some of the more important metals in the following tables:

Malleability.	Ductility.	Tenacity.[1]	
Gold.	Gold.	Iron	549 lbs.
Silver.	Silver.	Copper	302 "
Copper.	Platinum.	Platinum	274 "
Tin.	Iron.	Silver	187 "
Cadmium.	Copper.	Gold	150 "
Platinum.	Zinc.	Zinc	109 "
Lead.	Tin.	Tin	34 "
Zinc.	Lead.	Lead	27 "
Iron.	Nickel.		
Nickel.	Palladium.		
Palladium.	Cadmium.		
Potassium.			
Sodium.			
Mercury (frozen).			

Gold is the most malleable, as well as the most ductile, of the metals, and under the hammer is capable of a degree of attenuation without a rupture of its continuity that seems almost incredible, leaves of it having been produced the $\frac{1}{300000}$th of an inch in thickness, each grain of which is capable of covering a surface of 54 square inches. Increase of temperature as a rule diminishes the tenacity of metals, heat overcoming the cohesive force of the molecules. In the case of a few of the metals—notably zinc, aluminum, and magnesium—their malleability is greatly increased by a slight elevation of temperature. It is impossible to roll zinc into sheets at ordinary temperatures, owing to its extremely brittle nature, but by heating the ingots to about 300° F. it becomes quite malleable and is readily rolled down into thin sheets. If heated much beyond this point, it becomes quite brittle again, and if made hot enough may be easily pulverized in a mortar.

Elasticity, or the quality of returning to its original form after being bent, and *Sonorousness,* the quality of emitting a musical sound when struck, are properties which belong only to the harder metals, and are developed most highly in some of the alloys.

Odor and *Taste* are properties of some of the metals, and are most marked in the cases of copper, iron, and tin, in which metals they are characteristic.

[1] Weights, omitting fractions of pounds, sustained by wires 0.787 of a line in diameter.

Alloys.

Notwithstanding the varied qualities which the metals possess by reason of their widely-differing physical and chemical properties, the infinite requirements of the useful arts constantly demand modifications of these which the pure metals fail to meet, and to obtain which various combinations of the metals with each other are resorted to. It is to these metallic combinations that the term *alloy* is applied.

The word "alloy" is believed to be derived from the French *aloi* (the metal of the standard coin), a contraction of *à la loi* (according to the law). The alchemists, who divided the metals into "noble" and "base," also used the term to express a combination of the former with the latter, in which case its nobility was said to be "alloyed" or "allayed." When one of the metals composing an alloy is mercury, the combination is called an *amalgam*. As the amalgams are a large class, and of special interest and importance in dental practice, they will be treated of separately from alloys, in which mercury does not enter as a constituent.

As the number and character of metallic combinations are virtually infinite, differing not only in the number of their component metals, but likewise in the quantity of each, and as there are many obstacles at present in the way of a systematic scientific study of their chemical character, any classification of them will be necessarily imperfect, but for all practical purposes the classification suggested by Matthiessen[1] affords by far the most satisfactory method for their intelligent study. He regards it probable that "an alloy is either (1) a solution of one metal in another, (2) a chemical combination, (3) a mechanical mixture, (4), or a solution or mixture of two or all of the above." That these conclusions are warranted becomes evident from a study of the behavior of the various metals toward each other upon alloying them. Several of the metals when melted with each other unite apparently in the same manner that sulphuric acid mixes with water, in all proportions indefinitely, forming a perfectly homogeneous mixture with no tendency to separate upon cooling. To this class belong the alloys of tin with lead and of zinc with tin, in which the component metals dissolve in each other without any definite limit, and in every particular appear to be analogous to true solutions: they do not partake of the nature of chemical compounds, as they retain the physical and other properties of their constituents, or those of the one in excess in direct proportion as it predominates in the mixture.

Though no well-defined line of demarcation exists between the laws which govern the formation of solutions and those of chemical combinations, yet certain marked differences in the results produced are evident. When we examine a body which is the result of the union of two or more elements by chemism or chemical affinity—or, in other words, a true chemical compound—we find that it possesses properties in every way differing from those of the elements of which it is composed: thus, hydrogen, an inflammable gas, and oxygen, likewise a gaseous body and an energetic supporter of combustion, when united

[1] *British Association Reports*, 1863, p. 97.

chemically form a liquid, water, which is neither inflammable nor a supporter of combustion.

A characteristic feature of all chemical compounds is that their constituents are invariably found to be united in exact proportions by weight. No matter in what quantities they may be brought together, it is always found after combination takes place that a definite quantity by weight of one is united with a definite quantity by weight of the other.

On the other hand, in the class of compounds termed solutions, while some of the properties of the constituents may be modified or to a certain degree lost, yet they always possess to a greater or less extent the properties of their component substances: thus, sodium chloride when dissolved in water has all of the chemical properties which it possessed in the solid state. This holds true of all solutions, and is a peculiarity not shared in any degree by what are strictly called chemical compounds.

There is little doubt that in many if not the greater number of alloys the laws of quantivalence and chemism are factors of their formation, giving rise to the production of metallic compounds the component parts of which are united in equivalent atomic ratios. This is indicated by the energy which attends their union in some instances, and the definite crystalline form of many of the alloys, notably those of copper with tin. The tendency of metals to unite in definite proportions may be verified by cooling a melted mixture slowly, and when partly solidified pouring off the liquid remnant (as in the familiar experiment of making sulphur crystals), when crystals are left which are always combinations in the proportions of the atomic weights of the component metals. Examples of metals combined in definite proportions frequently occur in nature, as, for instance, the native alloy of gold with silver, in which four, five, six, or twelve atoms of gold are found combined with one of silver. All metals do not unite indifferently with each other, but have varying affinities for each other, depending greatly upon their relative positions in the electro-chemical series; thus, silver will hardly unite with iron, but combines readily in all proportions with gold, copper, tin, lead, etc.; or, again, zinc, which has little or no affinity for lead, combines readily with tin, copper, silver, etc. The superior affinity of certain metals for each other is well illustrated in the manufacture of alloys of copper, tin, and antimony; thus, if 10 parts of antimony be added to 90 parts of copper and 10 parts of tin, an alloy will be produced having qualities differing materially from an alloy made by adding 90 parts of copper to 10 parts of tin and 10 parts of antimony. Though in each instance the component metals are the same and united in the same proportions, yet in the first the antimony is added to a compound already formed of copper and tin, while in the latter the copper is added to a formed compound of antimony and tin, and may be viewed as a solution of the tin-antimony combination in a menstruum of copper, while the first instance may be regarded as a copper-tin combination holding antimony in solution, thus furnishing alloys of widely-differing physical properties.

Practically, nearly all alloys, especially those made artificially, belong to the third and fourth groups of Matthiessen, as before noted—*i. e.*

they are either "mechanical mixtures" or they are "solutions or mixtures of all of the foregoing classes."

Alloys of copper and lead, commonly called "pot-metal alloys," furnish good examples of mechanical mixtures: the constituent metals, having little or no affinity for each other, do not readily unite, and an examination of their fracture-surface by the microscope reveals the two metals side by side, the copper, combined with a small percentage of lead, forming a spongy network holding irregularly globular masses of nearly pure lead in its meshes. Such alloys are usually brittle and greatly deficient in tensile strength.

Advantage is taken of the non-affinity of copper and lead in the process of separating silver from copper by *liquation*, as it is termed; which consists in fusing the argentiferous copper with about thrice its weight of lead and casting the alloy thus obtained into cakes or disks, which are afterward heated upon a hearth so contrived that the lead, which melts much more easily than the copper, may flow off in the liquid state, carrying with it, in the form of an alloy, the silver which was associated with the copper, leaving this last metal upon the hearth in porous masses having the form of the original disks. The lead and silver are afterward separated by cupellation.

Where metals which have but little affinity for each other are alloyed, and it is necessary to produce castings which shall be as homogeneous as possible in texture, the mixture should be briskly and thoroughly stirred, and then quickly poured at as low a temperature as is consistent with a thorough filling out of all parts of the mould, in order that the alloy may solidify before segregation of the metals takes place. The tendency of the constituent metals in this class of alloys to separate during casting is largely counteracted by pouring them into "chill" moulds—*i. e.* moulds made of cast iron, in which solidification takes place almost instantly, yielding castings which present a much more uniform and homogeneous fracture-surface. The physical constitution of this class of alloys is in many ways analogous to the emulsions of oily substances and water, in which the oil-globules are merely suspended for a time in the aqueous menstruum, but upon standing separate into layers according to their relative specific gravity. In alloys this separation of the metals is termed "liquation."

As the requirements of the arts demand such an infinite variety of qualities in metallic combinations, and the properties conferred upon alloys by even slight variations in the proportions of their constituents are so widely different, the number of such combinations has multiplied indefinitely with little or no regard to their chemical structure, and has given rise to the fourth class of combinations before noted. Many of the more familiar alloys are of this class, such as brass, gun-metal, the various bronzes, etc. The elaborate investigations of Levy and Kunkel, undertaken for the Russian Government in 1867–68, which resulted in the discovery of the well-known phosphorus-bronze, and also the investigations of Prof. R. H. Thurston of the Stevens Institute of Technology in the *Report of the U. S. Board appointed to Test Iron and Steel and Other Metals*, show that copper and tin tend to unite in definite atomic proportions, but when combined in other than these, as in

gun-metal, the resulting alloy is a solution or mixture of an alloy of copper and tin in atomic proportions with an excess of copper, the addition of other metals producing a more complex mixture, which, if chemically united, may confer upon the resulting alloy properties wholly different from the original metals, or if simply dissolved or mechanically mixed the alloy may partake to some extent of the nature of the component metals.

Physical Properties of Alloys.—The changes in the physical properties of the metals produced by alloying them cannot before experiment be at all anticipated; even slight variations in the relative proportions of the ingredients of an alloy produce marked changes in the properties of the product. The specific gravity of alloys varies greatly, and may be either greater or less than the mean of the specific gravities of their component metals. Examples of these are given below, as determined by Thénard:[1]

Alloys having a *greater* Specific Gravity than the Mean of their Components.		Alloys having a *less* Specific Gravity than the Mean of their Components.	
Gold	and zinc.	Gold	and silver.
"	" tin.	"	" iron.
"	" bismuth.	"	" lead.
"	" antimony.	"	" copper.
"	" cobalt.	"	" iridium.
Silver	" zinc.	"	" nickel.
"	" lead.	Silver	" copper.
"	" tin.	Copper	" lead.
"	" bismuth.	Iron	" bismuth.
"	" antimony.	"	" antimony.
Copper	" zinc.	"	" lead.
"	" tin.	Tin	" lead.
"	" palladium.	"	" palladium.
"	" bismuth.	"	" antimony.
"	" antimony.	Nickel	" arsenic.
Lead	" bismuth.	Zinc	" antimony.
"	" antimony.		
Platinum	" molybdenum.		
Palladium	" bismuth.		

With our present limited knowledge of the chemical structure of alloys, these differences in specific gravity are not easily accounted for; but, to reason by analogy, if we assume that in certain cases atomic combinations take place between metallic elements in the same way and according to the same laws which control combinations of non-metallic elements, then alterations in specific gravity become readily understandable upon the hypothesis of a condensation of volume due to an increase in the number of atoms in a molecule of the compound over the number of atoms in the molecules of the individual elements entering into such combination, and *vice versâ*.

The relation of the fusing-point of alloys to those of its constituent metals is also variable, and cannot be anticipated theoretically. The fusing-point of an alloy is always less than that of the least fusible metal which is contained in it, and often below the melting-point of the most fusible of its constituents. The curious alloys known as "fusible metal" well illustrate this. An alloy of 2 parts bismuth (which melts at 507° F.), 1 part lead (which melts at 617° F.), and 1

[1] *Practical Metal-Worker's Assistant*, Byrne.

part tin fuses below the temperature of boiling water, although the most fusible of the three metals, tin, requires a temperature of 442° F. to fuse it. Again, pure iron is extremely refractory, but when combined with a proper quantity of arsenic and phosphorus it may be melted in a cast-iron pot without adhering to it.

The properties of metals dependent upon molecular cohesion—viz. malleability, ductility, and tenacity—are greatly modified by alloying. In general, the malleability and ductility of alloys are greatly inferior to that of the pure metals possessing these qualities in a high degree. Thus, gold when debased by even minute additions of lead, tin, or arsenic has the above-named properties almost entirely destroyed. The extent to which the physical qualities of two metals may be changed by alloying them in varying proportions is well shown by the following table, from the investigations of Prof. R. H. Thurston,[1] in which copper is alloyed with zinc in increasing proportions of 5 per cent.:

<table>
<tr><th>No.</th><th>Copper.</th><th>Zinc.</th><th>Copper.</th><th>Zinc.</th><th>Color.</th><th>Hardness.</th></tr>
<tr><td></td><td colspan="2">Composition by original mixture.</td><td colspan="2">Composition by analysis.</td><td></td><td></td></tr>
<tr><td>1</td><td>95</td><td>5</td><td>96.07</td><td>3.79</td><td rowspan="8">Generally of a dark-yellow color, inclined to copper-red toward the copper end of the series.</td><td rowspan="8">All soft enough to be cut with a saw, the hardness gradually increasing from No. 1 to 8 with the increase of the proportions of zinc.</td></tr>
<tr><td>2</td><td>90</td><td>10</td><td>90.56</td><td>9.42</td></tr>
<tr><td>3</td><td>85</td><td>15</td><td>89.80</td><td>10.06</td></tr>
<tr><td>4</td><td>80</td><td>20</td><td>81.91</td><td>17.99</td></tr>
<tr><td>5</td><td>75</td><td>25</td><td>76.65</td><td>23.08</td></tr>
<tr><td>6</td><td>70</td><td>30</td><td>71.20</td><td>28.54</td></tr>
<tr><td>7</td><td>65</td><td>35</td><td>66.27</td><td>33.50</td></tr>
<tr><td>8</td><td>60</td><td>40</td><td>60.94</td><td>38.65</td></tr>
<tr><td>9</td><td>55</td><td>45</td><td>55.15</td><td>44.44</td><td rowspan="3">Similar to above, but darker and approaching to brown.</td><td rowspan="3">Much harder than the above, but could be cut in the lathe with a good tool.</td></tr>
<tr><td>10</td><td>50</td><td>50</td><td>49.66</td><td>50.14</td></tr>
<tr><td>11</td><td>45</td><td>55</td><td>47.56</td><td>52.28</td></tr>
<tr><td>12</td><td>40</td><td>60</td><td>41.30</td><td>58.12</td><td rowspan="3">Nearly white.</td><td rowspan="3">Could not be cut in the lathe; almost as hard as glass.</td></tr>
<tr><td>13</td><td>35</td><td>65</td><td>36.62</td><td>62.78</td></tr>
<tr><td>14</td><td>30</td><td>70</td><td>32.94</td><td>66.23</td></tr>
<tr><td>15</td><td>25</td><td>75</td><td>25.77</td><td>73.45</td><td rowspan="5">Bluish-gray.</td><td rowspan="5">Hardness decreases with the proportion of zinc.</td></tr>
<tr><td>16</td><td>20</td><td>80</td><td>20.81</td><td>77.63</td></tr>
<tr><td>17</td><td>15</td><td>85</td><td>14.19</td><td>85.10</td></tr>
<tr><td>18</td><td>10</td><td>90</td><td>10.30</td><td>88.88</td></tr>
<tr><td>19</td><td>5</td><td>95</td><td>4.35</td><td>94.59</td></tr>
<tr><td>20</td><td>0</td><td>100</td><td colspan="2">Cast zinc</td><td>A little lighter than the above.</td><td>A little softer than the above.</td></tr>
</table>

Tenacity in most instances is markedly increased by alloying; thus, cast copper, which has an absolute tensile resistance of from 19,000 to 20,000 pounds per square inch, when alloyed with 10 per cent. of tin has its tensile strength increased to from 25,000 to 30,000 pounds per square inch, varying somewhat according to the methods employed in melting and casting it. Gold when alloyed with copper has its tenacity increased nearly 100 per cent.; the same holds true of alloys of gold with silver and with platinum. The addition of these metals to gold also increases its hardness, producing alloys of that metal of the proper qualities and texture for dental plates, clasps, springs, etc.

An alloy employed to some extent in Paris as a base for artificial

[1] *Report of the Board on Testing Iron, Steel, and Other Metals*, vol. ii., 1881.

dentures, known as Dr. Von Eckart's alloy, consisting of the following proportions: platinum, 2.40; silver, 3.53; and copper, 11.71—all of which in their pure state are soft, ductile, and malleable metals—is highly elastic, is of the same specific gravity as silver, is highly sonorous, bears hammering while red hot, and can be highly polished. It does not lose its elasticity by annealing, and from $\frac{1}{8}$ of an inch in diameter may be drawn into the finest wire without annealing.

An alloy of silver with 10 per cent. of platinum is much harder than either of its constituents, and more capable of resisting the tarnishing influences of sulphur compounds.

The practice of adding a certain percentage of copper to the noble metals used for coinage, plate, etc. is a familiar illustration of the increase in hardness often produced by alloying.

Color.—Changes in color result from alloying the metals, the product generally partaking of or resembling that of the predominating metal. A marked exception may be noted, however, in the case of an alloy of 3 parts silver to 7 of gold, which produces a greenish alloy used in jewelry and ornaments. Alloys of copper with nickel, when the latter metal is much above the proportion of 10 per cent., are almost white, the red color of the copper being obscured or wholly neutralized. Copper when alloyed with zinc yields the well-known "brass," which is of a rich yellow tint—a color entirely different from either of its component metals.

Sonorousness.—This quality is developed in the highest degree in some of the alloys, those of copper containing from 18 to 30 per cent. of tin, commonly called "bell-metal," being used for the manufacture of gongs, bells, cymbals, etc. The corresponding alloys of copper with aluminum are also remarkably sonorous, yielding bells of exquisite tone.

Conductivity.—The conducting power of alloys for heat and electricity is inferior to that of the pure metals. Advantage is taken of the high electrical resistance in some of the alloys, such as "German silver," for measuring the resistance of long lines of telegraph wire, the electro-motive force or working power of batteries, etc., the low conductivity of a wire of given dimensions of such an alloy furnishing a convenient standard for comparison.

While great differences may exist between the physical properties of an alloy and those of the metals composing it, yet certain of the metals when present in an alloy confer upon it definite properties which are in many instances characteristic; thus, in general, mercury, cadmium, and bismuth increase fusibility; tin, hardness and tenacity, according to the proportions present; arsenic and antimony nearly always produce brittle alloys, etc.

Nearly if not all of the oxidizable metals when fused have the power of dissolving to a greater or less extent the oxides formed by contact of the air with their molten surfaces; this is particularly true of alloys, especially those of a readily oxidizable metal with one which is less so. The metals being in a state of solution, a condition most favorable to chemical change, oxidation takes place rapidly. A striking illustration of the tendency of certain metals to unite with oxygen under such con-

ditions may be observed in the case of an amalgam of aluminum, which when exposed to the air instantly loses its lustre, becomes heated, oxidizes rapidly, and is converted into alumina and metallic mercury. Water decomposes it rapidly with evolution of hydrogen, formation of alumina, and deposition of mercury.[1] The same effect can be shown by rubbing a globule of mercury over the surface of a polished plate of aluminum with a piece of chamois or buckskin. The mercury unites after a short time with the aluminum surface, but almost immediately oxidation commences, with sensible evolution of heat and the development of an efflorescent deposit of alumina on the plate, which grows visibly to the naked eye.

In some of the alloys, as those of copper and tin, as much as from 2 to 5 per cent. of the oxides formed will be dissolved unless means are taken to prevent it. The effect of these dissolved oxides is to produce an alloy greatly deficient in toughness and strength. Under the microscope a fractured surface of such an oxidized alloy shows the surface of each crystalline particle to be covered with an adhering film of oxide which prevents their perfect metallic contact, thereby reducing their cohesive power. The detrimental influence of dissolved oxides in copper and tin alloys has been carefully determined by Levy and Kunkel, who found that such an alloy, kept in a state of fusion for some time, with free access of air, when cast had a tensile strength of 22,982 pounds per square inch; the same alloy partially deoxidized by stirring it briskly with a stick of green wood, or "puddling" it, when cast had a tensile strength of 24,972 pounds per square inch—a gain of over 2000 pounds; while the same alloy completely deoxidized by the addition of a minute quantity of phosphorus had a tensile strength of 33,916 pounds per square inch—a gain of nearly 11,000 pounds of cohesive power over the alloy containing much dissolved oxide.

The author's investigations have shown that the property of reducing metallic oxides in bronze alloys is shared in an equal degree by metallic arsenic.[2]

The protection of molten metals from contact with the air is usually accomplished by covering them with a layer of pulverized charcoal or by the use of some one of the various fluxes, such as borax, common salt, pulverized glass, sal ammoniac, etc.

A familiar instance of the detrimental effect of dissolved oxides is seen in the case of zinc used for making the dies upon which to form dental plates. After repeated meltings with free access of air, it becomes thick and pasty upon fusion, and does not fill out the mould sharply. It is readily restored to its former working qualities by throwing upon its surface a small quantity of some substance rich in carbon, such as wax, rosin, or tallow, and stirring the melted metal briskly with a stick for a few minutes, by which the dissolved zinc oxide is reduced to the metallic state, giving to the metal its former bright and clean appearance.

Preparation of Alloys.—When it is desired to unite two or more

[1] *Comptes rendus.*

[2] See specification of U. S. letters patent, No. 201,536, granted to Edward C. Kirk for improvement in bronze alloys.

metals to form an alloy, two principal sources of loss are to be guarded against: 1, Loss by oxidation; 2, loss by volatilization. The first is accomplished, as before noted, by the use of one of the fluxes or charcoal. In all cases where alloys of the noble with the base metals are to be made, borax is by far the most satisfactory material for the purpose. Loss by volatilization is most likely to occur where an easily fusible metal is caused to unite with one which fuses with difficulty: in such a case the metal or metals requiring a high temperature should be melted first under a sufficient layer of borax. When fusion is complete the more fusible metal should be quickly thrust below the surface of the flux, when combination of the metals will take place almost instantly, after which they can be cast.

Soldering is the process of uniting two metallic surfaces, either by direct fusion of the contiguous portions or by the intervention of a more fusible metal or alloy, and, while not, strictly speaking, a metallurgical process, is so closely related, and the principles which it involves are to so a great extent those which govern the formation of alloys, that it may properly be considered under the latter head.

The first process by which union is effected through direct fusion of contiguous portions, without the aid of a more fusible metal or alloy, is termed the autogenous method, and has its largest application in the manufacture of articles of sheet lead, such as tanks for the reception of sulphuric acid, sewer-traps, etc. The edges to be united are scraped clean and pressed together, after which a strip of pure lead is placed along the joint. The pointed flame from a compound blowpipe burning illuminating gas or pure hydrogen and air is directed upon the joint until fusion is complete, yielding a seam much stronger than where tin solder is used. It has also the advantage of being less expensive and less oxidizable. No flux is necessary. Considerable dexterity and experience is requisite to ensure a successful result. It is also essential that the flame used for the purpose should be small and pointed, but develop a very intense degree of heat, in order that fusion should not extend beyond the limits of the seam. The oxyhydrogen jet is now in successful use in soldering many articles of sheet lead by this method, the intense heat generated by this blowpipe enabling the work to be done with great rapidity. Lead on account of its comparatively low power for conducting heat and its great fusibility is particularly well adapted for autogenous soldering. The intense heat projected upon the parts to be joined is not conducted away, as it would be in the case of a metal of high conductivity, so that fusion of the edge to be joined takes place at once, and is easily kept within the prescribed limits.

Iron and also brass are sometimes united by a somewhat similar method, by encasing the parts to be joined in moulding sand in their proper relative positions, leaving a vacant space or chamber about the joint. A charge of melted iron or brass, as the case may be, is poured, rather hotter than usual, into the chamber and around the ends to be joined, the excess of metal overflowing into the pit below. This is continued until partial fusion of the ends takes place, when the whole is allowed to cool, and the pieces will be found to be homogeneously united.

In all cases where two metallic surfaces are caused to unite by interposing a metal or alloy more fusible than the metals to be united, the process is simply one of superficial alloying. In order to bring about combination of two metals, it is not always necessary that both should be brought to a state of fusion: if one of them is liquefied, union readily takes place if their mutual attraction is sufficiently energetic; thus, a strip of clean copper immersed in melted zinc for a time may be converted into brass. Iron under suitable conditions when dipped into a bath of melted zinc becomes coated with an adherent film which consists of an alloy of zinc and iron. So strong is the solvent action of the zinc on iron that small articles made of the latter are often completely dissolved during the galvanizing process.

It has been seen that, in general, alloys fuse more readily than their least fusible constituent. The attachment is stronger the more nearly the solder and the metals united by it agree as to strength, ductility, malleability, etc.; and in all cases the metal or alloy used as a solder should resemble the metals to be united as nearly as possible in all physical characteristics except fusibility, which must of necessity be lower.

The union of two surfaces of platinum by means of fine gold furnishes one of the best illustrations of the soldering process. If a clean strip of platinum-foil, for example, has a globule of pure gold fused upon it, the latter will be seen to spread itself out under the action of the heat until it has covered a considerable surface. If the heat is discontinued just at the moment that fusion of the gold is complete, it will be found upon examination that the platinum has been covered with a firmly-adherent film of gold exhibiting its characteristic golden-yellow color. Upon applying a heat sufficient to fuse the gold again, and continuing it for some minutes, it will be found after cooling that the gold color has entirely disappeared, this being due to the fact that the gold has alloyed itself with or dissolved sufficient of the platinum to neutralize its color. When two platinum surfaces are united by flowing pure gold between them, the same thing takes place: a portion of gold unites with each plate or surface, alloying with it to a certain extent, while a film of pure gold or nearly pure gold completes their continuity. If the heat is sufficiently intense and prolonged, the gold film grows richer in platinum, becomes more infusible, and the platinum surfaces are more intimately united by the gold-and-platinum alloy. This may be observed in the process of making artificial dentures by the continuous-gum method. When the teeth-pins are first soldered to the stays and plate by pure gold, the yellow color of the latter metal is everywhere plainly discernible, but upon breaking up a set which has been completed it will be found that the gold color has completely disappeared, and the joints will be found to be united by a gold-and-platinum alloy produced by the high temperature necessary for the fusion of the body and enamel. It will also be noticed that by heating a joint between two strips of platinum-foil made with fine gold as a solder to the melting-point of the latter, they can be readily pulled apart while the gold color is apparent, but after combination between the gold and platinum has fully taken place this can be done only with difficulty.

The case is precisely similar in soldering with other metals and

alloys, except that where alloys are used as solders their composition becomes in some instances more complex. Union of the solder takes place with the heated surface of the metal to be joined, dissolving it to a slight extent to form an alloy, which completes the continuity of the two surfaces upon cooling.

In all cases the metals to be soldered must be well fitted to each other and chemically clean in order that a minimum quantity of solder may be used, and that it shall readily unite the surfaces to be joined. If an excess of solder is used, particularly where thin plates of metal are to be united, as in the soldering of stays or backings to a dental plate, the unfortunate result of melting down the backings or burning a hole through the plate may be brought about, owing to the sudden formation of a large body of alloy of lower fusibility than the plate metal by its union with the fusible solder. A much stronger plate and less liability of fusing the plate or backings result from the use of a minimum amount of solder.

Absolute cleanliness of the surfaces to be united is an essential prerequisite, after which a flux is used to dissolve the oxides which are formed at the high temperatures reached, this being necessary in order to ensure bright metallic surfaces, without which union cannot take place. The source of heat for small work is generally a lamp or gas flame, intensified by the blowpipe operated either by a foot-blower or by the mouth, the piece being previously brought to near the fusing-point of the solder by a small charcoal or gas furnace. The blowpipe flame is then projected upon the work at the points where it is desired that the solder shall flow, the capillarity of the crevices forming the joint leading the fluid solder into the required places. The special applications of soldering to various methods for producing dental mechanism, with details for each process, are fully treated under their appropriate heads.

Amalgams.

Alloys having mercury as a constituent are called "amalgams." "The term is derived from the Greek *malagma*, from *malassō*, to soften, the presence of mercury lowering the melting-point of such a mixture."[1] Most metals—and even hydrogen, according to Leow—form amalgams. The interesting series of alloys to which the general term amalgams is applied present no features of chemical composition and structure in any way different from those alloys which do not have mercury as a constituent, and the theoretical considerations previously applied to the study of alloys in general, in their chemical aspect, together with the classification suggested by Matthiessen, hold equally good in relation to the mercurial alloys or amalgams. Their peculiar *physical* properties, such as great fusibility, the property of "setting" or hardening into dense, compact masses from a pasty or semifluid condition by virtue of their common constituent, mercury, and their extensive use as a filling material in the treatment of dental caries, warrant their special consideration here.

[1] Attfield, *Chemistry, General, Medical, and Pharmaceutical*, 1883.

Mercury alloys or unites readily with most of the metals: this is one of its most striking qualities, which is of value in many ways, notably in the extraction of gold and silver from their ores. The attraction of gold for mercury is readily seen when the two metals are brought into contact. A sheet of gold-foil suspended above the surface of mercury becomes covered after a time with a silvery coating of mercury even at ordinary temperatures. Iron and platinum are the only metals in common use that can be employed in contact with mercury without becoming coated or corroded by it. Mercury, however, adheres to platinum. Like all other metals, mercury tends to form definite compounds with certain of the metals. The following amalgams in definite atomic proportions have been formed with the metals named by combining them with mercury and squeezing out the excess by means of hydraulic pressure to the amount of 60 tons per square inch:

Amalgam of lead,	Pb_2Hg.	Amalgam of zinc,	Zn_2Hg.
" " silver,	$AgHg$.	" " copper,	$CuHg$.
" " iron,	$FeHg$[1].	" " platinum,	$PtHg_2$.[1]

The amalgams of silver, $AgHg_2$ and $AgHg_3$, as also the mineral arguerite, Ag_6Hg, are found crystallized in nature.

One of the chief applications of mercury in the arts is in the so-called "silvering" of glass, which in reality consists in coating one side of the glass with an amalgam of tin, which is accomplished by laying a sheet of tin-foil of the same size as the glass to be covered upon a level surface and rubbing metallic mercury over it, after which a thin layer is poured upon it. The glass is then carefully slid on to the amalgamated tin sheet, its edge carrying before it any impurities and part of the superfluous mercury. Heavy weights are then laid upon the glass, and in a few days the amalgam of tin will be found strongly adherent to the glass. The coating usually contains about 1 part mercury to 4 parts of tin.

An amalgam of gold is used in the process known as "fire-gilding," which previous to the discovery of the methods of electro-deposition of metals was the only process for gilding known. It consists in brushing or rubbing over the surfaces of objects to be gilded an amalgam of gold, from which the mercury is afterward volatilized by heat, and the adherent gold burnished into a compact film. Silver deposits were made in a similar manner, but the processes were prejudicial to health by reason of the mercurial vapor set free during the operation, and the advent of new processes based upon electro-chemical methods has rendered the use of mercury in these cases obsolete. An amalgam of 6 parts of mercury, 1 part of zinc, and 1 part of tin is used to promote the action of certain frictional electrical machines. Amalgams used in dental practice for filling cavities in carious teeth are composed, in general, of an alloy which is first formed of two or more metals, usually silver and tin, with the addition of either one or more of the following metals: gold, platinum, zinc, or copper. These are melted and cast, after which the ingot of alloy is comminuted by a cutter in the lathe or by filing, and mixed with the quantity of mercury necessary to form a coherent mass of the

[1] Bloxam's *Chemistry, Inorganic and Organic.*

proper working qualities, which is then ready to be introduced into the cavity of decay.

A vast amount of experimentation has been done in order to produce amalgam alloys for dental use which shall possess the requisite properties for that purpose in the highest degree. These are conceded to be, when finally inserted—1, immutability as to form; 2, sufficient density, hardness, and toughness to resist attrition and fracture at the edges; 3, complete resistance to the action of the oral secretions and food; and 4, stability of composition, by which molecular change is avoided.

Binary Amalgams.—The metals which have been used in the formation of dental amalgams are—tin, silver, gold, platinum, copper, zinc, palladium, cadmium, and antimony. Tin unites readily with mercury, forming an amalgam which is friable and not sufficiently hard for use as a filling material. The tendency to assume a spheroidal form, and draw away from the edges of any cavity into which it has been packed, has been observed in this amalgam. As to its expansion or shrinkage, accurate data are wanting; some observers claim that it expands, while others state that it contracts. In combination with other metals in dental alloys it renders them more plastic when amalgamated, retards setting, and is not readily discolored. Tin and mercury show a disposition to unite in atomic proportions to form a weak crystalline compound.

Silver in a state of fine division, such as precipitated silver, unites readily with mercury with considerable evolution of heat; the mass hardens in a few seconds. In the state of filings union with mercury takes place more slowly. The investigations of Mr. Fletcher[1] and Mr. Kirby show that the silver amalgam undoubtedly expands on setting; according to the latter gentleman, the expansion amounts to $\frac{1}{40}$th of the diameter of the plug. It has been already shown (see p. 575) that silver forms definite chemical compounds with mercury. It is an essential constituent of nearly all dental amalgam alloys at present, owing to the hardening and setting qualities it imparts to them by reason of its affinity for mercury, with which it unites chemically to form crystalline compounds. The silver amalgam is readily discolored by sulphur compounds.

Gold and mercury unite readily, the union being greatly facilitated by heat; they form an amalgam which does not become hard enough to answer the purpose of a filling material. Combined in the proportions of 6 parts mercury to 1 part gold, the amalgam crystallizes in four-sided prisms. Mr. Fletcher states that "gold added to amalgams retards their setting quality," but the researches of Prof. Essig[2] show that this is probably an error. It renders amalgam alloys more plastic, imparts density and greater edge-strength, and renders them less liable to discoloration or corrosion. According to the investigations of Dr. W. G. A. Bonwill, the addition of more than 7 per cent. of gold in an amalgam alloy is not desirable, the best results being obtained when the quantity added does not exceed that amount.[3]

Platinum does not unite with mercury unless in the finely-divided form known as "spongy platinum:" if the latter is worked in a warm

[1] *Dental Metallurgy*, Fletcher. [2] *Ibid.*, Essig, p. 52.
[3] *Dental Cosmos*, vol. xxiv. p. 422.

mortar with mercury, combination takes place, resulting in a very smooth and plastic amalgam, which, owing to its extreme fineness, soils the hands upon working it, but which, however, does not harden sufficiently for use as a filling material. The pasty platinum amalgam is sometimes used for covering silver and other metals with a film of platinum by a process the same as for "fire-gilding."

Platinum under proper conditions (see p. 810) confers upon amalgam alloys several desirable qualities—viz. rapid setting, greater hardness, resistance to chemical action, and immutability as to form. Added in excess, it renders the alloy brittle.

Copper when finely divided unites readily with mercury, forming an amalgam which has the property of hardening again after being softened by heat. The amalgam known as Sullivan's cement or Sullivan's amalgam consists of 3 parts of copper to 6 or 7 parts of mercury, and is made by precipitating metallic copper from a weak solution of its sulphate by rods of zinc, and washing the precipitated copper with sulphuric acid, after which the proper proportion of mercury is added, together with a small quantity of nitrate of mercury to hasten and facilitate amalgamation. All excess of mercury is then to be removed by squeezing in a cloth, after which the mass can be rolled out into small cylindrical pieces and allowed to harden. According to Mr. Fletcher, "it is an absolutely permanent filling, as the copper salts penetrate and perfectly preserve the tooth. If after a time the filling is removed, the decay is still permanently arrested, owing to the protecting action of the copper salts absorbed. The intense black color of the teeth in which this alloy is used is the only objection to its use, as the loss in weight by solution in the mouth is so small as not to be injurious, although the alloy is intensely poisonous if dissolved." Copper confers upon amalgam alloys properties similar to those imparted by platinum—viz. increased hardness, rapidity of setting, etc.—but "it has not the power to control changes of form, which it is claimed is a property belonging only to platinum" (Thomas Fletcher). Its preservative qualities render it a valuable constituent in alloys for use in teeth of a low grade of structure.

Zinc unites readily with mercury, and forms a definite alloy having the formula Zn_2Hg. With a larger amount of mercury an amalgam is formed similar to the copper amalgam, but too brittle for use as a filling. The amalgam of zinc is not acted upon by dilute sulphuric acid; hence the amalgamation of zinc plates used in batteries prevents their wasting while the battery is not in use, solution of the zinc taking place only while the *circuit* is closed. In dental amalgam alloys zinc is said to control shrinkage and render the alloy incapable of discoloration and quick setting. Dental alloys containing zinc have a peculiar grayish-white appearance when amalgamated, rendering the filling less conspicuous when inserted in exposed situations. Many of the so-called "front-tooth" alloys contain zinc.

Palladium, precipitated from a solution of its chloride by metallic zinc or iron, and afterward washed with dilute nitric acid and dried, furnishes the metal in a form most suitable for union with mercury. The palladium amalgam sets slowly or rapidly according to the amount

of mercury added, the best results being obtained by a very quick-setting amalgam, under which circumstances it becomes exceedingly hard. The experiments of Mr. Tomes,[1] and also those of Dr. E. A. Bogue,[2] tend to show that as a filling material the palladium amalgam has all of the preservative qualities of the copper amalgam, without its objectionable feature of discoloring the tooth-structure, though the filling itself turns quite black after a time. Fletcher states that "fillings of palladium amalgam contain generally from 70 to 80 per cent. of mercury." According to Mr. Tomes, the amalgam of palladium shrinks less in setting than any of the binary amalgams. "Palladium combined with other metals in an amalgam renders them worthless" (Thomas Fletcher).

Cadmium as a constituent of amalgams was first introduced to the profession by Dr. Evans of Paris in 1848. It has the remarkable property of imparting to amalgam alloys the quality of malleability. Its use is strongly condemned for the following reasons: Its strong affinity for sulphur causes a rapid formation of cadmium sulphide, resulting in discoloration of the tooth-structure and disintegration of the filling; it is also believed by some to produce irritation and death of the pulp, and to decalcify tooth-substance in contact with it. As a component of dental amalgams it has proven so unsatisfactory that its use has become obsolete.

Antimony has been used as a constituent of dental alloys. It is said to render the alloy finer-grained and to control shrinkage (Prof. Henry S. Chase). It renders the amalgam very uncleanly in mixing, which constitutes the principal objection to its use, and it does not prevent discoloration.

Ternary Amalgams.—The metals above noted have been variously combined with each other in order to produce alloys which when amalgamated and used as filling material shall possess in the highest degree the properties requisite for the purpose, as before stated—viz. density and edge-strength, resistance to chemical action, and immutability of form. There is good reason to believe that these results are more nearly attainable in alloys whose constituents are united in equivalent atomic proportions, or, in other words, in which the metals form true chemical compounds with each other; but many practical difficulties are still to be overcome, not the least of which is the necessity for accurately weighing the exact quantity of mercury necessary for the combination before such a result can be achieved, so that the alloys which are at present in use, though they undoubtedly contain such metallic chemical combinations, are really solutions of one or several atomic alloys in an excess of one or more of the other constituents.

It will be seen from the list of amalgam alloys appended whose composition has been determined that they are all composed of a basis of silver and tin, with, in most cases, the addition of small proportions of one or more other metals for the purpose of overcoming the objections which are inherent to those two metals when used alone as an amalgam.

[1] *Trans. Odontological Soc. Great Britain*, vol. iv., 1872, p. 135.
[2] *Dental Cosmos*, vol. xxii. p. 196.

Tin and silver as an alloy unite readily with mercury, forming a white plastic amalgam, which contracts upon setting and oxidizes readily. In most mouths it turns black after a time, owing to the formation of silver sulphide. With this, as with all dental amalgams, widely differing results are obtained, varying with the method of mixing and the quantity of mercury used. The writer has tested this point with an alloy containing, besides silver and tin, $1\frac{1}{2}$ per cent. of gold and one-half of 1 per cent. of platinum, in the following manner: In the first instance, the filings were added to pure mercury until the mass was sufficiently dry and homogeneous for introduction into the cavity without squeezing out any mercury, all excess being taken up by the addition of filings of the alloy. With this mass a distal proximal compound cavity in an upper sixth-year molar was filled. Another portion of filings was taken, and mercury added in excess to form a thin pasty amalgam; from this the mercury was squeezed with heavy pliers through chamois leather, and the resulting amalgam mass used to fill a cavity upon the mesial proximal surface of the twelfth-year molar in the same mouth, contiguous to the one first mentioned; both were done at the same sitting. After one month had elapsed the first one inserted was quite dark, while the second one remained bright. After two years the conditions were about the same, the first one being much discolored, while the last one retained its brightness. Repeated experiments in this direction tend to confirm the author's belief that *discoloration* in this class of amalgams can be in most cases controlled in the manner of mixing by adding mercury in excess, and then removing the superfluous mercury from the mass by squeezing it in chamois with strong pliers. By such a procedure there can be little doubt that the atomic proportions of the ingredients are more nearly secured, as the metals of the alloy take up all the mercury necessary for their complete saturation—using the latter term in its chemical signification—yielding a chemical mercurial compound of the metals composing the alloy, from which the excess of mercury holding in solution that portion of the alloy not required in the formation of the atomic combination is largely removed by straining through the chamois-skin by pressure. It has been urged that this method of mixing produces an alteration in the relative proportions of the component metals of the alloy, which is undoubtedly true; at the same time, until some method is devised by which absolute uniformity in the composition of various samples of the same makes of alloys can be obtained, and when this is done the exact proportionate quantity of mercury required to produce the best amalgam mass from it is determined accurately, the method of adding an excess of mercury and removing the same by pressure from the mass will undoubtedly yield the best results, on theoretical grounds at least; and experience would seem to warrant the practical value also of the method named. Prof. Essig has shown[1] the necessity for exact proportions between the mercury and the silver and tin: he found that with 500 milligrams of an alloy composed of silver 40 per cent. with tin 60 per cent., mixed with 160 milligrams of mercury, the resulting amalgam

[1] *Dental Metallurgy*, Essig, p. 50.

withstood the action of sulphuretted hydrogen quite as well as alloys which contained gold and platinum.

The feature of discoloration of amalgams is probably due in great degree to the want of chemical union of their constituent metals, it having been already shown that where the alloy is only a simple solution of one metal in another, and particularly where one of them is a readily-oxidizable metal, the minute state of division in which it exists favors chemical change, by reason of the infinite number of points or surfaces of contact which it presents to chemical agents. Gold and platinum are believed to prevent discoloration, and this property is also shared by zinc.

The addition of gold and platinum to the alloy of tin and silver confers upon such an alloy, when amalgamated, several valuable properties. Prof. Essig found that the addition of platinum alone in any considerable quantity to an alloy of silver and tin impaired its qualities. "Platinum, however, when added to an alloy of gold, silver, and tin, confers upon such an alloy the property of almost instantly setting, as well as much greater hardness. The valuable qualities claimed for platinum, *per se*, belong in reality to the combination of tin, silver, gold, and platinum with mercury, since if either one of the others is omitted the platinum does not even remain passive, but actually by its presence causes marked deterioration of the qualities essential in a dental amalgam."

The use of platinum as an ingredient of dental amalgam alloys was suggested by Thomas Fletcher, as it was found by him to control changes of form during the time the amalgam was hardening, and to hasten the setting.

Gold in sufficient quantity reduces the tendency of amalgams containing platinum to soil the hands while mixing—a quality produced by platinum, and due, according to Fletcher, to the "perfect fit" of amalgams containing it.

Gold in combination with tin and silver, without platinum, forms with mercury an amalgam which hardens rapidly and has sufficient density and edge-strength for a filling material. The alloy is less liable to chemical change than the alloy of tin and silver alone. The addition of gold also largely controls shrinkage.

The marked effect of gold in reducing contraction of the amalgam of tin and silver is well shown by the following table, the result of a series of experiments by Charles S. Tomes in which gold was added in successively increasing proportions to an alloy consisting of 45 per cent. of silver and 55 per cent. of tin:

Parts.	Parts.	Increase of specific gravity.
Silver, 4.5; Tin, 5.5		.33.
Silver, 4.5; Tin, 5.5	+ Gold 1	.16.
Silver, 4.5; Tin, 5.5	+ Gold 2	.086.
Silver, 4.5; Tin, 5.5	+ Gold 3	.055.
Silver, 4.5; Tin, 5.5	+ Gold 4	.037.

The figures in the right-hand column represent the apparent gain in weight due to contraction of the mass in setting; and as the amount of contraction is proportionate to the increase of density, these figures indicate the relative proportionate contraction of the alloys with variable additions of gold. In the last alloy, which contains nearly 30 per cent., the author states that "it is possible that the diminution in shrinkage may be simply due to the amalgam hardening less perfectly." In regard to these alloys of silver, tin, and gold, Tomes states that "they keep a beautifully bright surface, retaining very minute impressions, so that within moderate limits the addition of gold effects a very definite improvement." The amount of contraction observed in the last alloy in the list was identical with that of the palladium amalgam tested in the same manner under like conditions. It seems evident, from the above experiments of Mr. Tomes, that with the increasing amounts of gold added a point is reached at which chemical combination of the mercury with the component metals of the alloy fails to take place completely, as the mass hardened less perfectly and, in direct proportion to the increase in amount of gold added, required a longer time to set, while shrinkage or contraction, as measured by the specific-gravity test, decreased in direct ratio to the weakness of the chemical combination. The observations of Dr. Bonwill (see p. 806) upon the use of gold in dental amalgam alloys also tend to confirm the idea that beyond a certain point gold is of no value in such alloys.

"Robertson's alloy for filling teeth" consists of 1 part of gold, 3 of silver, and 2 of tin. The gold and silver are first melted, and the tin added at the moment of fusion. The alloy when cold may be finely pulverized. Equal quantities of the powder and mercury are kneaded together to form the amalgam for filling.

Zinc is added to amalgam alloys for the purpose of producing a white or grayish-white alloy, to be used in exposed situations. When added to tin, silver, and gold alloys, it hastens the setting of the amalgam, and when added in proper proportions is believed to control shrinkage and prevent discoloration to a considerable extent. The addition of zinc, however, makes the amalgam coarse-grained and the alloy difficult to amalgamate.

Copper, tin, and silver with gold form an alloy in many respects similar to the analogous alloy of platinum with tin, silver, and gold. Copper causes rapid setting, and forms an alloy with qualities more desirable as a material for filling than the silver-tin combination, but, according to Fletcher, is without power to control changes of form to the extent that platinum does in amalgams.

As has been already intimated, the proportion of mercury necessary to be added to an alloy in order to obtain the best results varies with the composition of the alloy, and is probably definite for each. Thus, with palladium the quantity of mercury has been found to be large—viz. from 70 to 80 per cent.; in the case of copper, 65 to 70 per cent.

Alloys containing gold and platinum require more mercury than the simple tin and silver alloys. It is therefore important that the correct amount of mercury required for the proper amalgamation of any given alloy should be accurately determined, which may be readily done by

adding mercury to a weighed portion of filings until the mass is of proper working quality, and again weighing, when the increase in weight will represent the amount of mercury added. When the method is pursued of adding mercury in excess and squeezing it out through chamois leather, the mixing by weight is unnecessary.

Several methods of combining the mercury and filings are in vogue, the one most frequently employed, perhaps, being that of dropping mercury upon the filings held in the palm of the hand, and kneading the mass with the thumb or fingers until union is complete. It has been suggested that sufficient mercury might be introduced into the system to produce physiological disturbance where this method is continuously pursued for a length of time, but evidence of any such trouble arising from this cause is wanting.

Combination of mercury and filings is also brought about when they are rubbed together in a mortar, or by the device suggested by Fletcher of using a tube of glass about four inches in length, in which the filings are vigorously shaken with the proper amount of mercury, the orifice of the tube being in the mean time closed by the thumb. The percussive force brought to bear upon the filings and mercury rapidly brings about union, and by this method soiling of the hands is avoided.

Formation of Amalgam Alloys.—The general directions given (see p. 801) for the formation of metallic combinations apply equally in the production of the special alloys which are used for making dental amalgams. It remains, however, to describe the apparatus required and method of manipulation, as well as the precautions necessary to be observed during the process.

An alloy consisting of gold, platinum, silver, and tin being a typical combination, the method of producing an alloy of these metals will illustrate the process sufficiently, little or no modification being necessary where other metals are used. The source of heat may be either a coke or coal fire, or, what is more convenient and well adapted to the purpose, one of the small injector gas furnaces devised by Mr. Fletcher for melting metals. The crucibles used in the work are either the refractory sand crucibles sometimes called Hessian crucibles, the French clay crucible, or the plumbago or graphite crucible; of these the latter is preferable. Having brought the crucible to a bright-red heat, a sufficient quantity of borax is to be dropped in and allowed to fuse and coat the whole inner surface, after which the silver and gold, with the platinum in small pieces, should be introduced and heated until thoroughly fused. When this is accomplished, the tin may be added, and the fluid mass poured into a suitable ingot-mould, after which it may be comminuted by means of a file or in the lathe with a cutter. Borax is used as a flux to prevent absorption of any portion of the metal by the pores of the crucible, to protect the molten mass from oxidation by contact with the air, to facilitate pouring, and to dissolve any oxides that may be formed and avoid loss of tin by volatilization. Loss of the latter metal, and consequent alteration of the relative proportions of the ingredients, are largely avoided by the method suggested and used by Dr. Ambler Tees: he recommends that the tin be fused

under borax in a separate crucible, and the gold, platinum, and silver when molten be poured into the melted tin.

The following table will show the composition by analysis of some of the principal dental amalgam alloys in use:[1]

	Tin.	Silver.	Gold.	Platinum.	Copper.	Zinc.	Cadmium.	Antimony.	Palladium.
Arington's (S. S. White's)	57.5	42.5							
Blackwood's G. & P. Alloy	56.85	42.00	0.50	0.15	. . .	0.50			
Best (Spencer & Crocker's) Old	61.5	34.5	. . .	0.5	3.5				
Chicago Refining Co.'s (Old)	56.00	37.00	5	2.00					
Chicago Refining Co.'s (New)	58.37	37.53	4.00	0.10					
Chase's Coppered Amalgam	50	50	. . .	. . .	10	. . .	. . .	5	
Chase's Plastic Tin Amalgam	50	50	. . .	. . .	. . .	. . .	. . .	7	
Chase's Alcohol Tight Amalgam	40	50	. . .	. . .	. . .	. . .	. . .	10	
Chase's Stannous Gold	40	40	20						
Chase's Incisor Tooth Amalgam	40	50	. . .	. . .	. . .	. . .	. . .	10	
Caulk's White Alloy	55.00	43.65	. . .	. . .	1.35				
Caulk's Par-excellence	61.75	27.25	0.15	0.25	10.60				
Crown Gold Alloy	52.85	47.00	.15						
Dawson's White Alloy	49.27	48.24	.05	. . .	. . .	2.44	. . .	. . .	Trace
Dawson's Superior Amalgam	63.55	31.85	0.65	0.15	2.35	1.45			
Dibble's White Amalgam	49.65	49.75	0.20	. . .	. . .	0.40			
Fry's Amalgam	53.80	44.35	. . .	0.90	. . .	1.05			
Fletcher's Gold Alloy (Old)	56	40	4						
Fletcher's Platinum & G. Alloy	50.35	43.35	3.35	1.30	1.65				
Flagg's Submarine	35	60	. . .	. . .	5				
Flagg's Facing	35	37	5	. . .	. . .	3			
Flagg's Contour Alloy	37	58	5						
Globe (S. S. White's)	53.36	44.74	1.50	0.40					
Grimes's Front Tooth (Old)	44	10	. . .	. . .	. . .	. . .	46		
Grimes's Plastic Platinized Gold									
Hood's Amalgam (Old)	60.25	37	2.75						
Hood & Reynold's G. & P. Alloy	50.40	44.30	3.80	.30	. . .	1.20			
Hood & Reynold's Sans Tache Alloy	50.00	47.90	. . .	. . .	0.30	1.80			
Holmes's Star No. 1 (Old)	59	40	1						
Holmes's Star No. 2 (Old)	58	39.5	2	0.5					
Hays's Pure White (Old)	51.5	43.5	. . .	1	. . .	4			
Hardman's Amalgam	44.57	50.12	. . .	. . .	5.31				
Hardman's White Alloy	50.56	44.57	.28	. . .	4.59				
High Grade Alloy, 7½ per cent. Gold	41.5	49	7.5	. . .	. . .	2			
Harris's Amalgam (Prof. J. H.)	48.10	40.00	. . .	. . .	4.90	7.00			
Johnson & Lund's Extra (Old)	60	38.00	1.5	0.5					
Johnson & Lund's Extra (New)	61.15	36.75	.15	.50	. . .	. . .	1.45		
J. & L.'s Virgin White Alloy	61.65	37.75	. . .	. . .	. . .	0.60			
J. & L.'s Atlas Amalgam	61.90	36.85	. . .	0.35	. . .	. . .	0.90		
J. & L.'s Extra Tough Alloy	51.25	47.00	0.30	0.20	0.25				
Justi's Superior G. & P. Alloy	59.10	35.20	0.32	0.08	3.50	1.80			
King's Occidental	54.75	42.75	. . .	. . .	. . .	2.50			
Lawrence's (Old)	47	47	1	. . .	5				
Lawrence's (New)	50.43	44.06	. . .	. . .	5.51				
Moffitt's (Old)	62	36	2						
(Moffitt's) The Dentist's Amalgam	59.50	37.90	. . .	. . .	. . .	2.60			
Oliver's Amalgam (Old)	50.8	46.1	1.7	1.4					
Oliver's White Amalgam (New)	55.25	44.74							
Pierce's (Old)	40	55	4	. . .	. . .	1			
Prof. Essig's (Old)	55	45	2.5	2.5					
Parsons's Eureka Silver Alloy	40.00	55.00	. . .	. . .	3.00	2.00			
Sterling Amalgam (Old)	62.00	31	1	. . .	6				
Sterling Amalgam, D. & L. (New)	62.37	33.20	. . .	0.14	4.33				
Standard Amalgam (Davis & Co.)	55.40	44.60							
Standard Dental Alloy (Eckfeldt)	40.60	52.00	4.40	. . .	3				
Shattuck's Standard Gold Alloy	51.74	46.98	1.20	0.08					
Sibley's G. & P. Alloy	54.65	43.15	0.20	2.00					
Temporary Alloy	88	10	. . .	. . .	. . .	2			
Townsend's (Old)	58	42							
Townsend's (Improved)	54.50	44.50	1						
Walker's (Old)	69	30.5	. . .	0.5					
Walker's Excelsior G. & P. Alloy	51.50	42.00	0.30	0.20	6.00				
Welch's G. & Plat. Alloy (Old)	54	44	1.3	0.7					
Welch's G. & Plat. Alloy (New)	51.90	46.00	1.70	.40					
Welch's Amalgam	51.52	48.48							

Liquation, or separation of the alloy into metallic combinations of different compositions arranged in the ingot in the order of their rela-

[1] By courtesy of Dr. J. O. Keller.

tive specific gravities, may generally be avoided by raising the temperature to a point considerably higher than is required to fuse the alloy, and then quickly pouring it into a cold iron ingot-mould, whereby solidification takes place instantly and before separation occurs. If the alloy is not poured hot enough, liquation may take place in the crucible, or the ingot will show a different composition at either end; this can be remedied only by remelting and casting at a higher temperature.

Analysis of Amalgams.—It frequently becomes important for the dentist to acquire a knowledge of the constituents of an amalgam alloy, as well as the proportions of each in a given combination. To this end the following method of analysis may be employed:

A weighed quantity of the alloy, usually one or two grams, is taken and acted upon by pure nitric acid in a glass flask by the aid of a gentle heat. The alloy should be in as fine a state of division as possible, in order that solution may take place as rapidly and completely as possible. A finely-divided condition of amalgam alloys is necessary, otherwise the metastannic acid which is produced by the action of the nitric acid upon the tin forms a protective coating on the surface of the alloy, greatly retarding, if not in a measure preventing, its complete solution. When the solvent action of the acid is complete, there will be obtained a residue at the bottom of the flask with a clear supernatant liquid. Much can be learned of the constitution of the alloy by an examination of the contents of the flask at this stage. If the supernatant liquid is colorless, copper is absent, a very slight amount of copper being indicated by a distinct blue coloration. If the precipitated metastannic acid is white or nearly so, gold and platinum, at least in considerable quantities, need not be looked for, the presence of a small quantity of gold yielding a purplish tint to the metastannic acid, owing to the formation of purple of Cassius. The presence of platinum in considerable quantities is evident as a black powder; small quantities of this metal, however, are completely dissolved by nitric acid in the presence of a large excess of silver.

After filtering and carefully washing the precipitate, should it be white and pulverulent it consists of pure metastannic acid, and after drying may be weighed as such, unless antimony was present in the alloy, in which case it has been oxidized, and remains as an oxide along with the metastannic acid. Should the presence of antimony be suspected, the residue obtained as above should be fused in a silver crucible with sodium hydrate, by which antimonate and stannate of soda are formed. The fused mass is to be softened with water, and one-third of its volume of alcohol added to the solution and filtered. The precipitate of antimonate of soda may be washed with weak alcohol and weighed. The tin is recovered from the filtrate by precipitation with hydrogen sulphide, which after washing and drying is weighed as sulphide of tin. To the filtrate, which should be somewhat diluted, hydrochloric acid is added until no more precipitate is formed. After the precipitate has fully subsided the supernatant liquid is to be decanted, and the chloride precipitate heated with a small quantity of nitric acid. After this some water and a few drops of hydrochloric acid are to be added, and the whole filtered. By this treatment the mercurous chloride which was

thrown down by the hydrochloric acid along with the argentic chloride is removed as mercuric chloride, leaving pure argentic chloride, which may be weighed as such, or by reduction with sodium carbonate it may be weighed as metallic silver. (See section on Silver.) The mercury can then be recovered from the filtrate as protochloride by precipitation with phosphorous acid, which may be collected on a filter, washed with warm water, dried at 100° F., and weighed. It of course is unnecessary to test for mercury in alloys which have not been amalgamated, the method just described applying only to the analysis of amalgam fillings the composition of which it is desired to know. Instead of estimating the mercury in amalgams by the humid method, as just described, the quantity may be determined by heating a weighed portion of the amalgam to redness, and again weighing, the difference representing the amount of mercury. The method only yields accurate results in the absence of metals which are easily oxidized or volatilized, and should when these are present be conducted in a hard glass tube in an atmosphere of hydrogen: the part of the tube in front of the assay, which should be as finely comminuted as possible, should be filled with powdered quicklime. The mercury under these circumstances may be collected and weighed if the free end of the tube is drawn down to a narrow point which dips into a condensing-flask, and the operation is conducted with the same care and in the same manner as the ordinary process of organic analysis in the combustion furnace.

The original nitric-acid solution, containing free hydrochloric acid, which is now free from gold, silver, tin, antimony, mercury, and platinum, may still contain copper, zinc, and cadmium. To separate these it is treated with sulphuretted hydrogen, by which the copper and cadmium are thrown down as sulphides; these are washed repeatedly, and treated with dilute sulphuric acid by the aid of heat, by which the cadmium sulphide is dissolved, from which solution the copper sulphide may be collected by filtration, dried, and weighed, and the cadmium sulphide reprecipitated from the sulphuric-acid solution by sulphuretted hydrogen, and dried and weighed in like manner, or it may be thrown down by one of the alkaline hydrates and after ignition weighed as cadmium oxide. Zinc remaining in the solution can be thrown down as an insoluble carbonate, washed and ignited, and weighed as oxide.

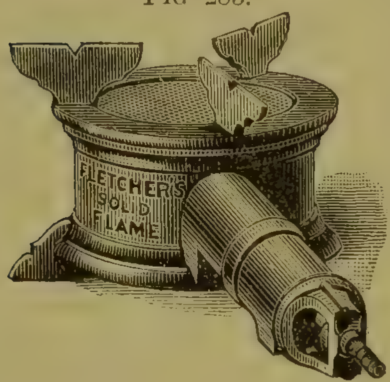
For the estimation of gold and platinum in alloys containing tin, two methods may be pursued. Either the tin may first be removed by deflagration—which consists in fusing the alloy in a borax-lined crucible and projecting into the fused mass small portions of potassium nitrate until the tin is all converted into potassium stannate, after which the resulting metallic globule consisting of gold, silver, and platinum is weighed, and the tin which was present estimated by difference—or the insoluble residue obtained upon dissolving the original alloy in nitric acid may be fused with potassium carbonate and cyanide, and the resulting button alloyed with pure lead and cupelled, the tin being estimated by difference as before. The button, which at this stage is composed of silver, gold, and platinum, is subjected to the parting operation by sulphuric acid. (See section on Gold.) The method of parting by sulphuric acid is used on account of the solubility of plati-

num in nitric acid when that metal is largely alloyed with silver. The gold and platinum, after weighing to obtain the amount of silver by difference, may then be separated by dissolving the ribbon in aqua regia and precipitating the platinum by ammonic chloride, which yields the metal in a condition for weighing upon ignition. The gold may then be thrown down by ferrous sulphate or oxalic acid, after which it should be carefully washed, dried, and weighed.

Melting Metals.

The fusion of metals is accomplished in various ways, depending upon the temperature necessary in any given case to bring about the result. For those which become fluid at a temperature much below redness, such as zinc, lead, tin, and their alloys, iron ladles are usually employed, and where the quantity operated upon is small, as in the making of dies and counter-dies for dental plates, they can be readily melted over a good-sized gas lamp in the laboratory, though where gas is not available, and where larger quantities are required, a coke or coal fire may be used. A gas lamp which gives satisfactory results in melting zinc and lead for dies and counter-dies, as well as for general laboratory heating purposes, has been devised by Mr. Fletcher of Warrington, Eng., who has given much attention to the economic uses of gas as a fuel in laboratory work, and is shown in Fig. 283. Gas mixed with the proper proportion of air from below is burned above the gauze top, yielding a blue flame, intensely hot and perfectly solid and uniform. The consumption of gas is about two cubic feet per hour for each square inch of gauze surface. It will melt an ordinary ladleful of lead in about ten or twelve minutes, depending on the gas-supply.

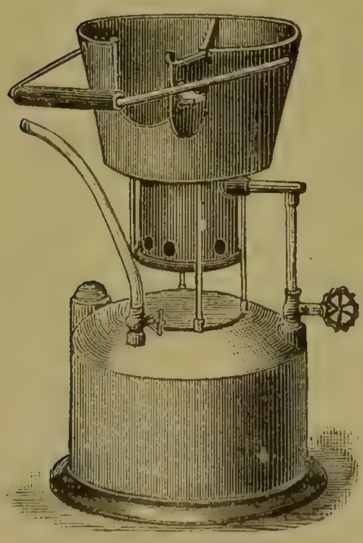
Fig 283.



Solid Flame Gas-burner.

For the melting of zinc and lead, and all alloys which can be fused in an iron ladle at or below a red heat, the author has used for two years with the greatest satisfaction one of the gasoline furnaces used by plumbers for melting solder. As now constructed, if used with ordinary care they are perfectly safe, and are without an equal for the convenience and rapidity with which they do the work, while the cost of fuel is but trifling. Fig. 284 gives an illustration of the furnace as now made. The lower portion is a galvanized iron reservoir which contains the gasoline. In the top of

Fig. 284.

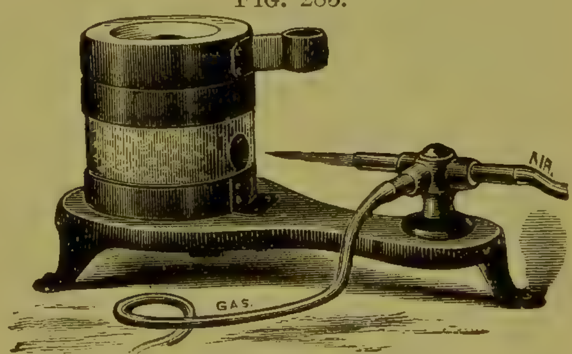


Gefrorer's Gasoline Furnace.

the reservoir is a stopcock with a short rubber tube attached, through which air is forcibly blown for a moment until pressure is made upon the surface of the gasoline, which forces it out through a tube which is continuous with the supply-tube of the burner reaching from the bottom of the tank and conveys it to the burner the supply to which is regulated by a valve. The burner is so constructed that the flame from the burning jet of gasoline is projected upon a recurved portion of the supply-tube, which is heated thereby to a temperature sufficient to vaporize the gasoline before it issues finally at the jet. The result is a large volume of gasoline vapor under high pressure, burning with an intensely hot flame, without any disagreeable odor, and with more than ample heating-power for the purposes noted. When once started, the action is perfectly automatic. The cast-iron shell around the burner directs the heat toward the sides of the melting-ladle, which stands within it and upon a support immediately above the flame. A gauze packing in the exit-tube interposed between the burner and the gasoline reservoir prevents any danger of ignition of the fluid in the latter while the furnace is in action. By means of this furnace, zinc may be readily heated to redness in a very short time. The form of the furnace made by C. Gefrorer, Philadelphia, and shown in Fig. 284, is the one best adapted for use with the Baily melting-ladles ordinarily used in the dental laboratory.

The melting of metals which require a higher temperature is accomplished either in a coke or coal furnace with a good draft, or where small quantities are operated on in the laboratory, as in the formation of dental amalgam alloys or alloys for dental plates, the injector furnace of Fletcher affords the simplest and most convenient means. It consists, as shown in Fig. 285, of a cylinder or casing with a perforated cover, both of which are made of fireclay which has been mixed with three or four parts by bulk of sawdust and burnt. Through an opening in the side near the base is injected a mixture of air and illuminating gas, which is accomplished by forcing a jet of air produced by a foot-blower through the column of illuminating gas, which is supplied to the mixing-chamber of the burner through the small tube at the side. The air-supply is regulated by the "air-check." With one of these furnaces the temperatures obtained are really surprising. According to Mr. Fletcher's experiments, "with half-inch gaspipe and the smallest foot-blower the smallest sized furnace will melt a crucibleful of cast-iron scrap in seven minutes, tool steel in twelve minutes, and nickel in twenty-two minutes, starting with all cold." The fusion of gold and silver and their alloys is readily accomplished in a few minutes by the use of the injector furnace. Where gas is not accessible, an ordinary stove where the draft is sufficiently strong may be used suc-

FIG. 285.



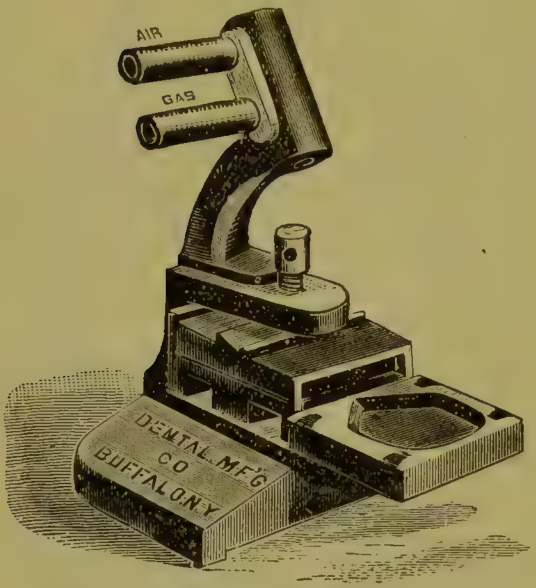
Fletcher's Injector Furnace.

cessfully for the same purpose, but the process is more troublesome and less rapid and cleanly.

The fusion of platinum can only be brought about by means of a furnace specially constructed of quicklime and heated by means of the oxyhydrogen blowpipe. The method of melting platinum is fully detailed in the section treating of that metal.

Small quantities of the precious metals are often melted by means of the blowpipe on a support made of charcoal or compressed carbon, which is contrived to do the double duty of crucible and ingot-mould. A sound piece of perfectly charred soft pine is divided vertically by means of a saw, and on the end of one half is carved out a depression to receive the metal to be melted; upon the flat surface of the other half is carved the depression which is to serve as the ingot-mould, the end of which must extend to the end of the block. The two halves are then firmly bound together with wire, and a gutter cut from the melting receptacle to the ingot-mould; the scraps can then be placed in the depression in the end of the block and fused by means of the blowpipe. When fusion is complete, by inclining the block sufficiently the fluid metal will run through the gutter into the ingot-mould, yielding in most cases a sound casting. It is claimed by many jewellers and dentists that ingots so cast are tougher and laminate better than those cast in iron moulds, from the fact that the metal is not chilled suddenly, and is therefore softer. This method is frequently pursued by jewellers and in the dental laboratory where quantities which do not much exceed an ounce are required to be melted. This method of melting small quantities of gold, silver, etc. has been in some respects improved upon, though the principle is the same, in the melting arrangement devised by Mr. Fletcher, shown in Fig. 286. It is practically a small reverberatory or "open-hearth" furnace, and consists of a shallow carbon crucible attached in front of an ingot-mould, the two halves of which slide upon each other, and can be clamped by the thumb-screw, thus furnishing ingots of any desired width. The stand and blowpipe are of one piece. The bottom of the stand is rounded at its posterior edge to facilitate the tilting of the apparatus. To use the arrangement, the scrap is placed in the crucible; gas is conducted through the lower tube of the blowpipe and ignited. Air from a foot-blower is forcibly blown through the upper tube, which throws an intensely hot flame upon the metal in the crucible. When the metal is completely fused the apparatus is tilted quickly backward, which allows the fluid metal to run into and fill the

Fig. 286.

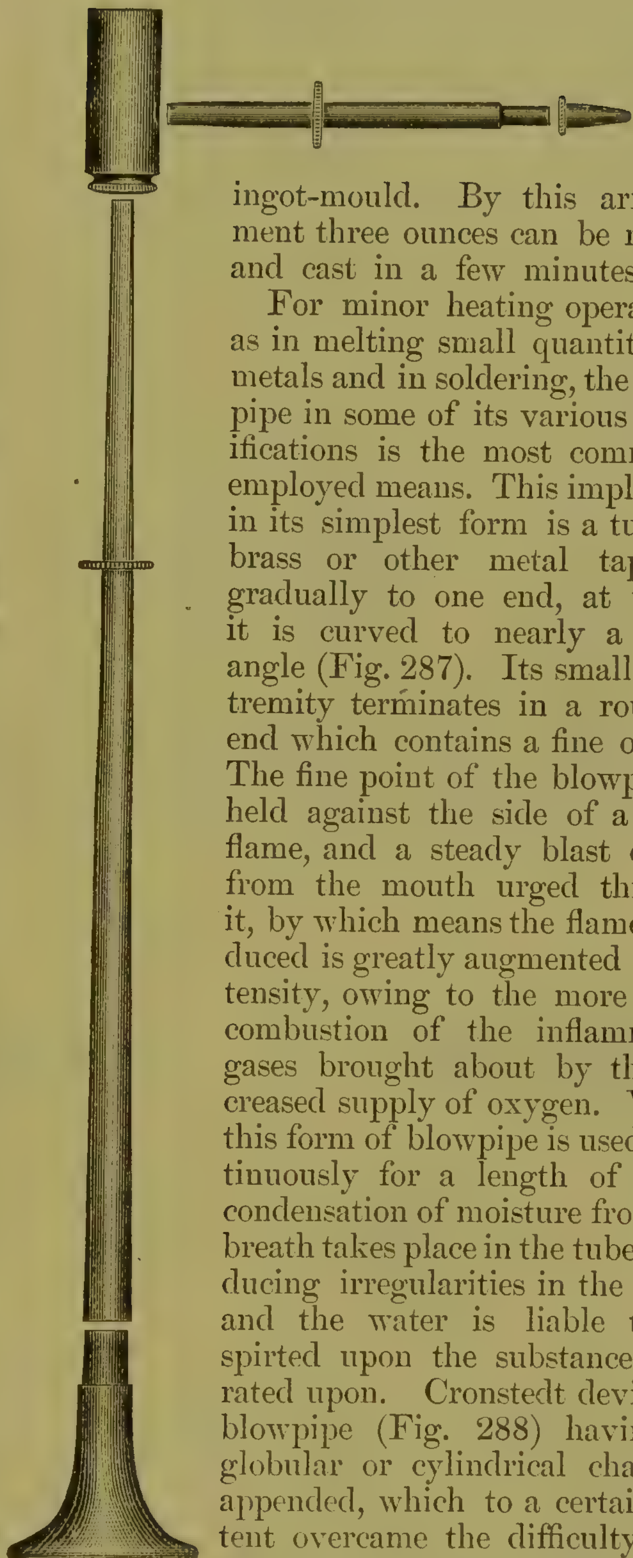


Melting Arrangement of Fletcher.

FIG. 287. FIG. 288.

Fig. 306. Plain.
Fig. 307. Chamber and Screw-joint.

FIG. 289.



Plattner's Blowpipe.

ingot-mould. By this arrangement three ounces can be melted and cast in a few minutes.

For minor heating operations, as in melting small quantities of metals and in soldering, the blowpipe in some of its various modifications is the most commonly employed means. This implement in its simplest form is a tube of brass or other metal tapering gradually to one end, at which it is curved to nearly a right angle (Fig. 287). Its smaller extremity terminates in a rounded end which contains a fine orifice. The fine point of the blowpipe is held against the side of a lamp flame, and a steady blast of air from the mouth urged through it, by which means the flame produced is greatly augmented in intensity, owing to the more rapid combustion of the inflammable gases brought about by the increased supply of oxygen. When this form of blowpipe is used continuously for a length of time, condensation of moisture from the breath takes place in the tube, producing irregularities in the blast, and the water is liable to be spirted upon the substance operated upon. Cronstedt devised a blowpipe (Fig. 288) having a globular or cylindrical chamber appended, which to a certain extent overcame the difficulty, but not wholly, for if the instrument is at all inclined after a considerable amount of water has condensed in the chamber, the water runs into the jet as before. Gahn's or Plattner's blowpipe is free from the objectionable feature just noted, and is the form commonly preferred by blowpipe manipulators. It consists

(Fig. 289) of a cylindrical head or chamber about an inch in length and half an inch in transverse diameter. Into one end of this cylinder a long tapering tube is fitted by a ground joint. A shorter piece, narrowing to a fine point, is similarly fitted to the side of the chamber some distance from its free end, so that condensation of moisture takes place in that portion of the cylinder beyond the point of union. This piece is tipped at its free end with a conical piece of platinum having an extremely fine perforation. A flaring or trumpet-shaped mouthpiece is sometimes added to prevent tiring the lips during protracted operations.

It is necessary in using the blowpipe to be able to produce a continuous, uninterrupted blast of air for several minutes. While apparently difficult, the art is readily acquired by a little practice, and consists in being able to force through the blowpipe the air contained in the mouth by compression of the cheeks while taking a full inspiration through the nose, communication between the mouth and nose being in the mean time cut off by contact of the velum with the dorsum of the tongue. By this procedure the respiratory organs are relieved from undue strain and a steady, continuous blast of air maintained.

The source of heat in blowpipe operations is a lamp or gas flame. Analytical operations by the blowpipe are usually conducted with a lamp burning lard oil from a broad and thick wick, though the flame from a large paraffin candle may be employed, but is objectionable from the tendency of the material to melt away from the wick on the side toward which the flame is thrown by the blast. This difficulty is obviated by the use of the blowpipe lamp of Berzelius (Fig. 290). It

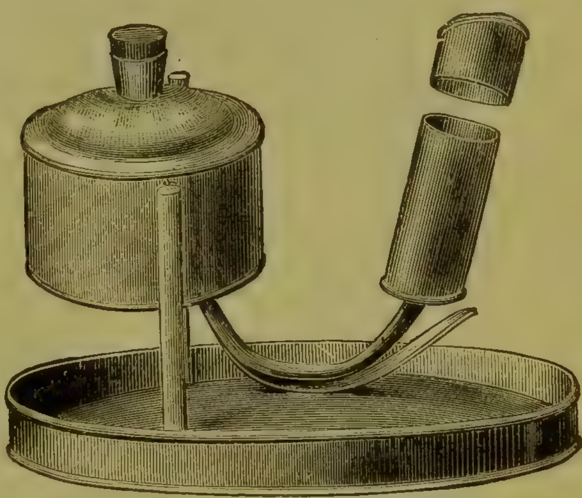
FIG. 290.

is made of brass or tinned iron japanned, about four and a half inches long and tapering somewhat toward the bottom, which is usually narrower than the top. At one end of the upper surface is the opening through which the lamp is filled, which is closed by a screw-cap. At the other end is the wick-holder, which may be also covered with a screw-cap, the object being to prevent the oil from spilling during transportation; this renders the lamp portable. The wick-holder is made oblique on its upper surface; the object to be heated is held at the side on which the wick is low, and the blowpipe tip held at the higher side. This arrangement secures a greater body of flame and a corre-

sponding intensity of heat. The lamp is clamped to an upright rod of brass which screws into two flat, heavy strips of the same metal at right angles to each other, which form the base of the stand. The parts can thus be readily separated and packed in the case for transportation—a matter of great convenience when testing or conducting assay work in the field.

For larger operations of melting and soldering when gas is not obtainable, a lamp burning alcohol or kerosene from a large wick is used. Care is necessary in the use of these, as, if the reservoir containing the fuel should become overheated, a dangerous explosion would most certainly ensue. The lamps best adapted for the use of alcohol or kerosene in large blowpipe operations are those in which the fuel reservoir is at some distance from the wick, and the burning fluid is fed to it by a small tube, as in the Franklin safety lamp (Fig. 291). The reservoir, which holds a pint or more of fluid, is connected to the wick-holder by a narrow tube five inches in length, so that no danger of heating the reservoir is incurred, while the connecting tube is sufficiently large to supply all the fluid necessary to the wick.

Fig. 291.



Franklin's Safety Lamp.

Whenever gas can be obtained, it furnishes at once the best and most economical, as well as safest, fuel for blowpipe work. A most convenient gas lamp, recommended by Prof. Essig,[1] consists of a piece of brass tubing six inches in length by one and a quarter inches in diameter. This is attached to the base of an ordinary Bunsen burner, and over the top of the tube a piece of fine brass wire gauze is fastened by means of a ring of sheet brass one-quarter of an inch in width. Connection is made with the gas-bracket by means of rubber tubing, and the gas lighted above the gauze. With the blowpipe this gives a flame suitable for most soldering operations and for melting small quantities of gold or silver.

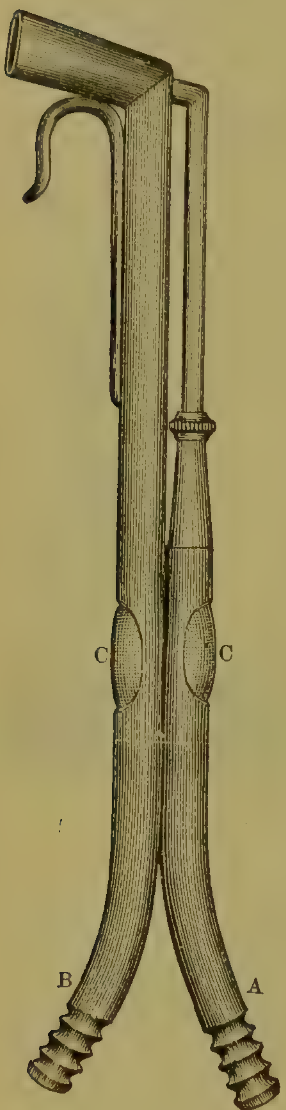
A practical objection common to each of the forms of blowpipe heretofore considered is the difficulty of maintaining a steady flame of uniform size, owing to the fact that the blowpipe and lamp used are separate, and the work must of necessity be adapted to the position of the flame, which is often inconvenient. In the form known as the compound blowpipe this difficulty is entirely overcome, and the size and direction of the flame, as well as its intensity, can be regulated and maintained in any required manner with the utmost precision.

Various modifications of the compound blowpipe have been devised to meet different requirements, but in general they consist of two concen-

[1] Essig's *Dental Metallurgy.*

tric tubes—one small and terminating in a fine jet, the other a larger tube slightly longer than the inner one at the jet end. Gas is supplied to the outer tube by an offset tube connected to the side near the opposite end, and flows through the space between the outer and inner tube, and is ignited at the open end; air is blown through the flame by means of the small inner tube, which terminates in the fine jet. It is essential for the production of the best results that the inner or air-tube should be accurately centred within the enveloping tube. In the author's experience, the most satisfactory arrangement of the compound blowpipe for soldering or melting small quantities of the precious metals is the form shown in Fig. 292, devised by Mr. Fletcher. Air is conducted through the tube A to the upper end of the gas-tube B, through which it passes, issuing from a small jet just within the orifice of the latter. The supply of both air and gas is regulated by pressure of the thumb or fingers upon the rubber tubes C, C. In this way the size and character of the flame are under absolute control, and may be varied at will with the use of but one hand and without disturbing the work. The whole arrangement being movable, the flame can always be projected upon the work without regard to its position. The blast from the mouth can be used with this instrument when a comparatively small amount of work is to be performed by it, but where very high temperatures are to be maintained for a length of time one of the various forms of mechanical blowers are necessary. Of these there are two satisfactory forms in use. The mechanical blowpipe of Burgess is a simple device for producing a continuous supply of air under pressure, giving a much stronger blast than can be obtained by the ordinary mouth blowpipe. It consists, as shown in Fig. 293, of a sheet-metal reservoir of cylindrical shape, underneath and connecting with which is a pump-cylinder in which the piston is worked by a treadle. A valve closes the opening between the reservoir and pump-cylinder. Air is compressed by the pump into the cylindrical reservoir, and escapes from the small opening at the top of the latter through a flexible rubber tube which conveys it to the blowpipe. The jet of air is rendered continuous by the elasticity, due to pressure, of the air in the condensing cylinder.

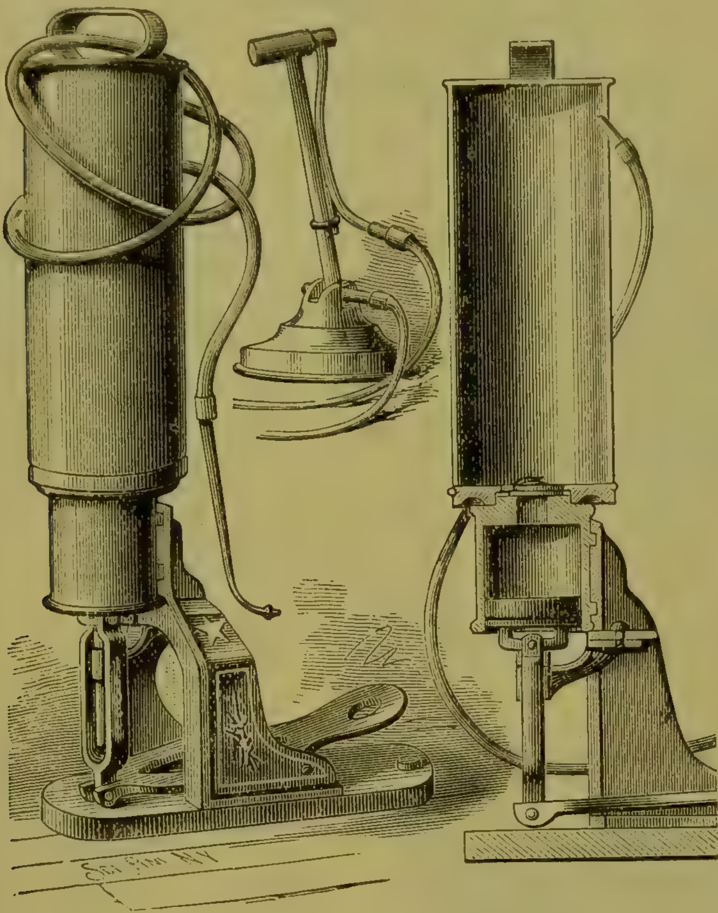
FIG. 292.



A larger volume of air is obtained by the use of the ingenious foot-blower of Mr. Fletcher, shown in Fig. 294. It consists of a single bellows operated by the foot. On its upper surface is attached by means of a raised flange a disk of heavy soft rubber sheeting, which becomes distended with air from the bellows through an opening in its top, which

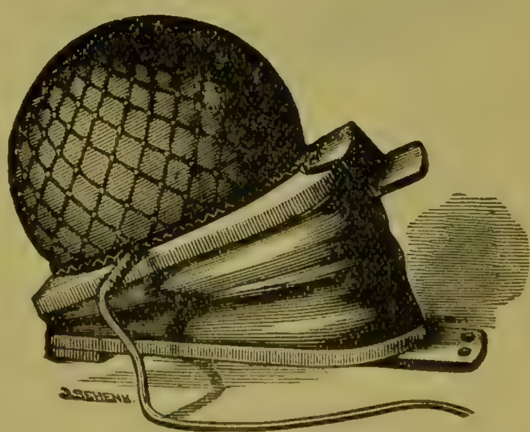
is fitted with an ordinary clapper valve. The elasticity of the sheet rubber maintains a constant and even pressure upon the air, and affords

FIG. 293.



a blast suitable for any form of compound blowpipe or for use with the injector furnace for larger melting operations. A coarse netting arranged outside the rubber disk prevents its over-distension. The whole arrangement is extremely simple and efficient. A recent improvement has been made in this apparatus by Mr. Fletcher which renders the rubber disk less liable to risk of injury, and consists in inverting the whole arrangement, by which the disk is placed upon the under side, so that it is free from any chance of particles of hot metal, etc. falling upon its surface and perforating it.

FIG. 294.

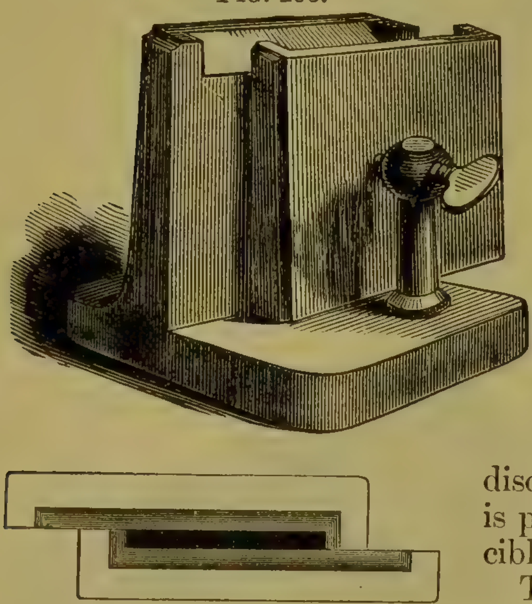


Crucibles.—A crucible is the vessel or receptacle in which the ignition or fusion of substances requiring high temperatures is performed. Crucibles are made of various refractory materials according to the nature

of the work to be performed. For the fusion of pure metals those composed of plumbago or graphite, commonly known as black-lead crucibles, are best adapted. They usually contain about 1 part of fire-clay to 2 parts of graphite, and are extremely refractory, being the variety used in the melting of steel. They are not suitable for the fusion of metallic oxides, as the latter are reduced to the metallic state at the expense of the carbon of the crucible, which is rendered weak and corroded thereby. They do not resist the action of oxidizing agents as well as sand or clay crucibles, and are best adapted for the fusion of pure metals, which require no chemical treatment in the crucible. The sand or Hessian crucible is composed of an extremely refractory clay, which has the composition, according to Berthier, of silica, 70.9; alumina, 24.8; ferric oxide, 3.8. They are used for rough fusions, for which they answer very well, but when used for the precious metals should always receive a lining of borax, as from their porous character they readily absorb considerable quantities of the molten metal. They are easily attacked by a number of the metallic oxides and alkaline fluxes, with which they form fusible compounds. Beaufaye's French crucibles are closer in texture, very refractory, and resist the action of metallic oxides and fluxes much better than the foregoing. They also bear changes of temperature well.

Crucibles are also made of porcelain, iron, silver, gold, and platinum, but these are rarely used in strictly metallurgical work, their use being almost entirely confined to the requirements of the chemical laboratory.

FIG. 295.



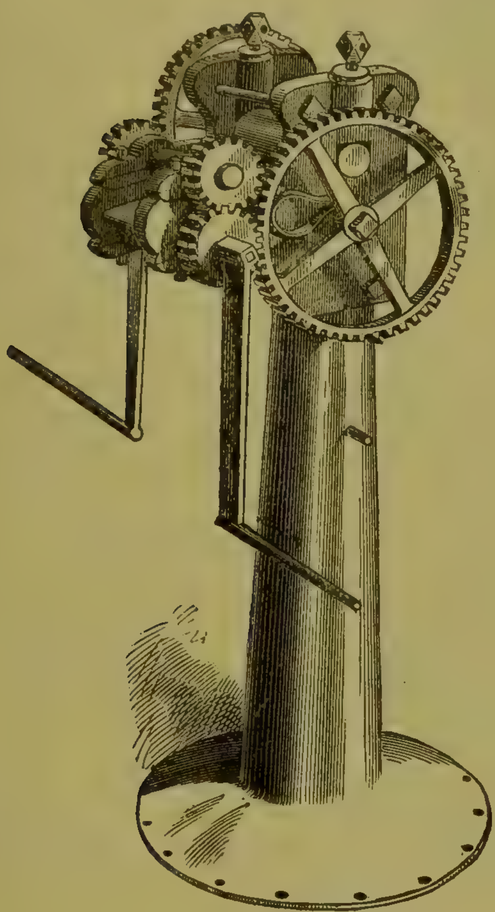
Before a crucible is used for the fusion of the precious metals it should always be tested to see that it contains no cracks or imperfections which might cause it to break during the operation and lead to the loss of part or all of its contents. It should always be heated to redness, very slowly at first, and then be allowed to cool, and if any imperfections are discovered it should be rejected. This is particularly required when new crucibles are used for the first time.

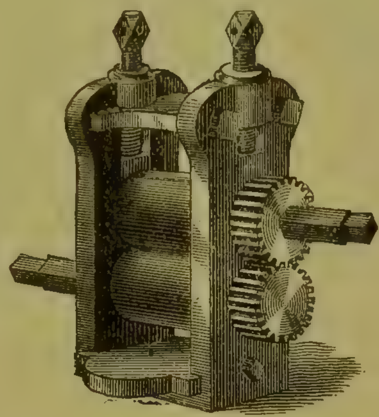
The fusion of platinum is accomplished either in a crucible of gas-carbon or in a receptacle carved in a block of quicklime, which forms part of the furnace to be described in connection with that metal.

Ingot-moulds are usually constructed of iron in various forms to meet given requirements. Those for gold and silver are generally of the form shown in Fig. 295, which is so made that the section next to the thumbscrew can be moved laterally upon the opposite half, so that the central cavity may be made narrow or wide, and thus furnish ingots

of any desired width up to the limit of the entire width of the mould, which is about two inches with a thickness of one-eighth of an inch. Ingots are frequently cast in moulds of soapstone or charcoal or compressed carbon, as previously described. Lime or coke is used to form

FIG. 296.



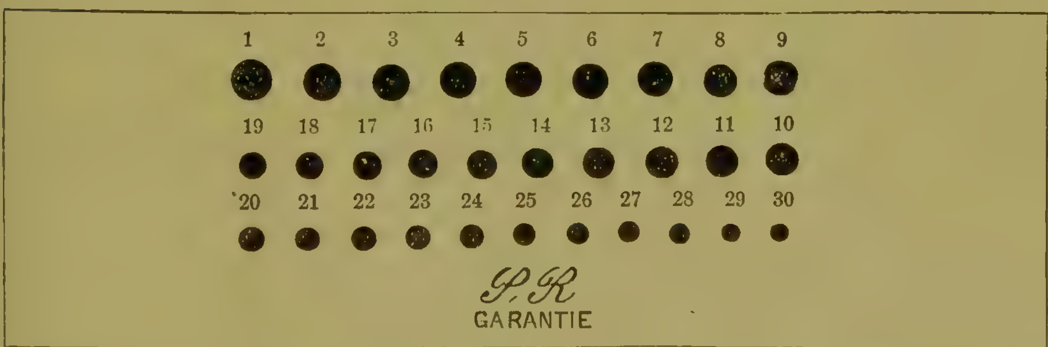


the moulds in which platinum is cast.

Lamination is accomplished by means of a rolling-mill (Fig. 296), which consists of a pair of polished hardened steel rollers connected by geared wheels, which are adjusted to each other and their distance apart maintained by means of two set screws. The ingot of metal is repeatedly passed through the rollers, which are brought closer together by means of the regulating screws until the required degree of attenuation is reached.

Extension of the metal in the form of wire is accomplished by means of a draw-plate (Fig. 297), which is a rectangular piece of steel plate

FIG. 297.



perforated with a number of conical holes gradually diminishing in size. The metal is drawn through these successively from the largest

FIG. 298.

until it is reduced to the desired size. Half-round, square, and triangular wire is drawn in the same manner, except that the holes in the draw-plate are made of these respective shapes, instead of being made round. In passing the wire through the draw-plate it is entered from the larger side of the conical hole, and the projecting end grasped with a pair of strong pliers or a hand-vise and steadily drawn through without stopping. If the metal becomes hard, it should be annealed from time to time. The thickness of both wire and plate is determined by the gauge-plate (Fig. 298).

NON-METALLIC COMBINATIONS OF THE METALS.

Combinations of the metals with the non-metallic elements take place in infinite variety, but according to well-defined chemical laws, and always in definite proportions by weight, yielding products partaking in no degree of the physical character of the elements entering into such combinations.

With the exception of the group of noble metals, nearly all are found in combination with one or more of the non-metallic elements in a state of nature, and it is these compounds which constitute their ores and are the sources from which they are produced by various metallurgical processes.

As all but the noble metals have a strong tendency to unite with oxygen to form oxides, it follows from the almost universal distribution of this element that the oxides form by far the most numerous and important class of metallic ores, and the principal metallurgic processes for reducing them to the metallic state have for their object the separation of the metal from its combined oxygen, or, in other words, its deoxidation. When this is accomplished the metal is obtained free from its non-metallic combination, and is said to be *reduced*. The various processes and methods requisite to effect the reduction of metals from their non-metallic combinations constitute metallurgic chemistry or metallurgy.

Metals combine with oxygen, as well as with other non-metallic elements, in different proportions and with varying degrees of affinity, yielding compounds on the one hand readily reduced or broken up—as, for example, mercuric oxide, which by a moderate heat is easily separated into oxygen and free mercury—or, on the other hand, the most refractory substance, such as alumina, the oxide of aluminum, in which the affinity between the oxygen and the aluminum is so powerful that

their separation by any direct process has until recently been found impossible.

The separation of metals from combined oxygen is usually effected by the aid of carbon at a high temperature by virtue of its superior affinity for oxygen under these conditions. The blast-furnace in which iron is reduced from its oxides furnishes a good illustration of this. A tall cylindrical furnace is filled with ore, fuel, and flux in certain proportions; the fuel is ignited, and air from a powerful blower is forced in at the base, which, coming in contact with the incandescent carbon, combines with it to form carbonic acid gas, CO_2. This in passing over the heated fuel takes up additional carbon, and is converted into carbonous oxide, CO—thus, $CO_2 + C = 2CO$—which at the high temperature of the furnace becomes a powerful reducing agent by reason of its affinity for oxygen, which it removes from the oxide of iron, and is once more converted into carbonic acid gas, $CO + O = CO_2$, while the iron is reduced to the metallic state, and is run off from a tap-hole at the base of the furnace. The reduction of copper, zinc, cadmium, and tin from their oxides is also effected by means of carbon in suitable furnaces.

The oxides of the metals in common use in the arts are fortunately all capable of being decomposed by means of carbon, which, on account of its wide distribution and consequent cheapness, makes it particularly valuable as a reducing agent from an economic standpoint. The smelting of metallic oxides, then, is simply a question of the best practical means for removing the oxygen combined with the metallic base. The process becomes more difficult or complex in proportion to the strength of affinity between the metal and its combined oxygen. Many metals, particularly those of the group called "noble metals," have but a feeble affinity for oxygen, and part with it easily at temperatures below redness without the aid of any other reducing agent. The oxides of lead, bismuth, antimony, zinc, nickel, cobalt, copper, iron, etc. require a strong red heat and the additional aid of a second body with a superior affinity for oxygen to combine with it and act as a reducing agent. While carbon, *per se*, must, on account of its cheapness and readiness of application, occupy the first place in the list of reducing agents, some of its derivatives are of great value and importance as deoxidizing agents. Carbon monoxide or carbonous oxide, CO, has a powerful affinity for oxygen at high temperatures, as was noted in the case of the ordinary blast-furnace for the reduction of iron from its ores. The same may be said of cyanogen, the monad radical formed by the union of carbon and nitrogen, $C^{iv}N'''$, though the most important reducing agent derived from carbon is the mixture of gaseous hydrocarbons produced by the destructive distillation of bituminous coal, and termed illuminating gas or carburetted hydrogen, which is essentially a mixture of marsh gas CH_4, olefiant gas C_2H_4, and free hydrogen, with small amounts of carbonic oxide, nitrogen, and sulphur compounds present as impurities. Coal gas as a reducing agent finds its largest application in the smelting of iron by the regenerative system of Dr. Siemens. The reduction is accomplished in a furnace of special construction known as the Siemens "rotator," which produces a remarkably pure quality of iron at a cost not greater than that required for the production of pig iron by the ordinary blast-fur-

naces (A. L. Holley). The natural gas of Western Pennsylvania is utilized largely for the production of iron and open-hearth steel by the Siemens system. All furnaces of the reverberatory type burning any carbonaceous fuel, with the exception of anthracite or coke, and used for smelting operations, depend for their reducing action upon the illuminating gas or carburetted hydrogen evolved from the fuel, which by the special construction of the furnace is projected upon the ore and flux in a highly-heated condition. The reduction of copper and tin ores is accomplished in furnaces of this character.

Pure hydrogen by reason of its affinity for oxygen is under suitable conditions a powerful reducing agent. This may be strikingly shown by forming a small quantity of cupric oxide, CuO, into a ball or cylinder by mixing it with a solution of gum arabic, and attaching it to the end of a copper wire about one foot long. After thoroughly drying the ball, it is to be ignited in the flame of a Bunsen burner, and while still hot plunged into the open mouth of an inverted jar previously filled with pure hydrogen. The ball will become intensely hot, and be rapidly reduced to metallic copper, while the water formed by the union of the hydrogen with the oxygen of the cupric oxide becomes evident as moisture in the form of dew upon the inner surface of the glass jar. By having another jar filled with oxygen and plunging the ball of reduced copper into it while still warm, the reverse effect is obtained: the copper is rapidly oxidized to CuO with the evolution of heat. By passing the ball from the oxygen jar to the hydrogen jar, and *vice versâ*, the alternate reduction and oxidation of the copper may be produced *ad libitum*.

Next in importance to the oxides of the metals are their binary sulphur compounds or sulphides. These form a numerous and important class of ores. The metals copper, zinc, lead, nickel, cobalt, antimony, bismuth, silver, and mercury are generally found associated with sulphur, and the principal processes for smelting them are to a great extent based upon methods for eliminating the combined sulphur.

In most cases calcination and roasting of the ore are first resorted to, by which means a portion of the sulphur is removed through conversion into sulphurous acid, SO_2, though in some instances if air is not freely admitted decomposition of the sulphide cannot be effected even at high temperatures. Thus, zinc sulphide or blende is unchanged by the highest temperature; the same is true of silver sulphide or silver glance. The sulphide of mercury, cinnabar, can be distilled without change; this is the case also with antimony sulphide and the two sulphides of arsenic—viz. orpiment and realgar.

By the operation of roasting, in which the sulphur-holding ore is subjected to the combined action of heat and atmospheric air for a length of time, either a partial or complete oxidation of the sulphur is effected, and the ore is converted into an oxide or one of a lower degree of sulphurization. In some instances the sulphur is oxidized sufficiently to form a sulphate of the metal, as in the roasting of galena or native lead sulphide, and also of copper sulphide. Zinc sulphide by continued roasting is wholly converted into oxide, from which the metal is reduced by carbon. The reduction of copper from its sulphide is accomplished by roasting the ore until a large percentage of sulphur is removed and

a portion of the copper oxidized. The temperature is then increased until a reaction ensues between the sulphide and oxide of copper, when the sulphur is oxidized and escapes as sulphurous acid gas at the expense of the oxygen of the oxide of copper; the metal thus reduced is afterward purified by further treatment.

The process for reducing lead from galena is essentially the same in the chemical principles involved—viz. the ore is roasted till a portion of the sulphide is converted into oxide, when the temperature is raised until all sulphur is removed as sulphurous acid by reaction of the sulphide with the oxide of lead, and metallic lead remains.

Compounds of metals with chlorine, bromine, iodine, and fluorine occur frequently in nature, and several such compounds constitute valuable ores. Of these, the silver compounds "cerargyrite" or "horn silver;" "embolite," which consists of chloride and bromide of silver in varying proportions; "bromyrite," which is the native silver bromide; and "iodyrite," the native silver iodide,—are important as ores of silver. Mercurous chloride also occurs native under the name of "horn quicksilver." All metallic chlorides, with the exception of those of the alkali metals and earths, are decomposable by a current of hydrogen gas with the aid of heat, hydrogen chloride being formed and the metal set free. As the more important chlorides from a metallurgical standpoint are those of the noble metals, the various methods for their reduction will be found under the description of the individual metal in each case.

The most powerful means for reducing metals from their non-metallic combinations is the galvanic current. The operation is termed "electrolysis." By its means the most refractory substances—viz. the compounds of the alkali metals, potassium and sodium, and those of the alkaline earths, calcium, barium, and strontium, as well as aluminum—have been successfully decomposed and their bases reduced to the metallic state. The recently-improved methods for producing powerful currents at greatly reduced cost by the dynamo-electric machine have given the application of electricity to the reduction of many metals an economic importance hitherto unattained.

The reduction of a number of the metals is readily accomplished by precipitation from solution by what are termed "wet processes." Thus, copper is reduced from a solution of its sulphate, and moist silver chloride is decomposed by means of iron plates. The "blue water" of copper mines, which is essentially a solution of cupric sulphate produced by the "weathering" or continued action of the atmosphere upon copper pyrites, is profitably treated and its copper obtained in a metallic state by suspending plates or quantities of scrap iron in it, when the sulphuric acid of the cupric sulphate combines with the iron to form ferrous sulphate, and the liberated copper is deposited as a fine spongy mass upon the pieces of iron; from these it is collected, washed, and fused into ingots.

Silver chloride is decomposed in a similar manner, though when on a small scale metallic zinc is frequently used instead of iron, in which case zinc chloride is formed by the union of the chlorine of the silver chloride with the metallic zinc, and the silver is deposited as spongy

silver. This method of reducing silver from its chloride is frequently used for the recovery of pure silver from the waste of photographic establishments, etc.

In the same way mercury can be readily reduced from its nitrate by metallic copper, a clean strip of copper being frequently used in qualitative analysis as a test for salts of mercury, the production of the characteristic white, mirror-like stain in the copper strip indicating its presence.

Gold.

Atomic weight, 196.2.[1] Symbol, Au (Aurum).

Gold is one of the metals earliest known to man, it having been used for jewelry and decorative as well as other purposes at periods of remote antiquity and previous to any historical records. Its early discovery was probably due to the fact that it is usually found in the metallic state. Its unalterability, beauty, and lustre have from the earliest ages caused it to be highly prized as an article of adornment and as a circulating medium as well as a measure of value.

Gold is widely distributed throughout the earth's surface, very few regions being destitute of some traces of it, though in the majority of localities the quantities are too small to pay for its extraction. Africa seems to have been the oldest and richest source of gold. Sofala, on the coast of Caffraria, has sands abounding in gold-dust, and is reputed to be the Ophir of the ancients. On the continent of Europe the gold-mines of Hungary and Transylvania are the most important. Some rich deposits also exist in the Ural Mountains; Siberia also yields gold; Sweden, Japan, Borneo, and Thibet contribute to the gold-supply. Immense quantities of gold have been obtained from Brazil, Chili, Peru, and Mexico. But by far the most important gold-producing districts are those of California and Australia. Its geological situations are the crystalline primitive rocks, the trachytic and trap rocks, and alluvial grounds. It is found in the form of small spangles or flattened grains, laminæ, irregular nuggets, or arborescent masses of variable size, in twisted threads with minute octahedral crystals, or sometimes in crystals of considerable size. It is never found constituting a vein by itself, like the baser metals.

Metallic gold, as it is found native, is never pure, but contains variable quantities of other metals united with it in no definite proportions. This is true even of native crystallized gold, as will be seen from the following analyses by Boussingault and Rose:

	Gold.	Silver.
1. Crystal from Transylvania	64.52	35.84
2. " " Marmato	73.45	26.48
3. " " Titiribi	76.41	23.12
4. " " Beresoff	91.88	8.03
5. " " Ekaterinburg	93.34	6.28

[1] This figure represents the atomic weight of gold, as last found by Levol in 1850. In accordance with its position in the periodic system of the elements, as proposed by Mendelejeff and Lothar Meyer, by which many atomic weights of doubtful accuracy have been corrected, it is probable that its atomic weight is somewhat greater than that of platinum (196.7).—Richter, *Anorganischen Chemie.*

Native gold may contain small quantities of other metals besides silver; thus, iridium is frequently a contaminating element in gold from California. Platinum is found in some specimens of Russian gold, while traces of palladium are sometimes found in gold from Brazil. Small quantities of copper and iron are not infrequently found in combination with native gold.

Analyses of Native Gold from Various Localities.[1]

	Gold.	Silver.	Iron.	Copper.
United States:				
California	90.12	9.01	6.15	
Europe:				
Vigra and Clogan	90.16	9.26	trace.	trace.
Wicklow (river)	92.32	6.17	0.78	
Transylvania	60.49	38.74	. . .	0.77
Asia, Russian Empire:				
Beresoff	91.81	8.03	trace.	.09
Ekaterinburg	98.96	0.16	0.5	0.35
Africa:				
Ashantee	90.05	9.94		
South America:				
Brazil	94.0	5.85		
Central America	88.5	11.96		
Titiribi	76.41	23.12	. . .	0.87
Cariboo	84.25	14.£0	. . .	.03
Australia:				
South Australia	87.78	6.07	6.15	
Ballarat	99.25	0.65		

In certain minerals gold is sometimes found in combination with other elements than those already mentioned; thus sylvanite (graphic tellurium) is a compound of tellurium with silver and gold in which the latter metal exists to the amount of 24 per cent. Nagyagite, a similar mineral, consisting of lead, gold, tellurium, and sulphur, contains from 5 to 9 per cent. of gold.

The sulphides of lead and iron, galena and pyrites, frequently contain variable quantities of gold, as well as some specimens of native arsenic and antimony: a native gold amalgam has also been found in California.

While native gold always contains variable proportions of other metals as impurities, yet gold from the same locality has commonly the same composition. The native gold of Australia is remarkably pure.

Methods for Extraction of Gold.—The simplest process for obtaining gold is that known as washing, by which gold is extracted from alluvial deposits, the sands of rivers, etc., and consists in agitating the gold-bearing sands and deposits with water, which carries off the lighter particles of earth and sand, while the gold, on account of its great specific gravity, remains in the bottom of the vessel in the form of small irregular or flattened grains called gold-dust. When the washing is carried on in the most primitive way in a round pan, the process is termed *panning out.* The deposits are sometimes thrown upon the top of a sloping plank having shallow grooves cut across it, into which the heavy particles of gold settle, while the lighter detritus is carried away by the stream of water which is allowed to flow over

[1] *Dental Metallurgy*, Essig.

it; some gold-washers employ long shallow troughs of wood lined with coarse baize cloth or tanned skins with the hair side upward, in which the grains of gold become entangled. After the earthy matters have been washed away the cloth or skins are beaten out over a tank of water to recover the gold.

Stamping is resorted to in order to reduce to a finer state the coarse gangue or quartz rock in which gold is often found, and to render it suitable for further treatment by washing and amalgamation. These last-named operations are sometimes performed at the same time in an apparatus called a cradle, from its swinging motion. It consists of a trough divided into two compartments: the upper one contains the ore, and the lower one mercury. A stream of water passes over the ore while the apparatus is being agitated, and carries away the earthy matter; the gold drops through a grating into the mercurial bath, and is there amalgamated.

Mercury has a powerful affinity for gold, and advantage is taken of its solvent action to separate gold from its earthy impurities. The ore, which has been concentrated by washing, is shaken with an excess of metallic mercury, either in small vessels by hand or in revolving barrels, until all the gold is dissolved. The process is greatly facilitated and the solvent action of the mercury increased by the addition to it of a small quantity of metallic sodium, which also prevents the condition of fine division of the mercury known as "sickening" or "flouring," which frequently arises before the point of saturation has been reached, and which occasions considerable annoyance from failure of the solvent power of the mercury because of the tarnish or imperfect state of its metallic surface. Loss of mercury also occurs from flouring, as it is readily washed away in that state.

When the point of saturation has been reached the amalgam is subjected to powerful pressure in leather bags, by which all excess of mercury is squeezed out through the pores of the leather, leaving a more or less coherent and rich amalgam inside. Final separation of all remaining mercury is then accomplished by distillation in iron retorts, the mercurial vapors being condensed for further use, leaving the gold in a spongy state in the retort, and usually free from other metals, with the exception of silver, from which it is separated by the *parting* process.

Extraction of gold from quartz rock is successfully accomplished by fusion with lead, which in the molten state has a high solvent power for gold, just as mercury has at ordinary temperatures. The crushed gold-bearing rock is fused with metallic lead, galena, or rich lead slag, with the addition of coal or charcoal to reduce the lead to a metallic condition; lime and clay also are added to form a fusible slag with the silica. The alloy thus formed of lead and gold, generally containing silver, is freed from lead by the process of *cupellation*.

Extraction in the Wet Way.—Gold is also extracted from gold-bearing quartz in the wet way by means of chlorine gas. The roasted and crushed ore is either subjected to the direct action of a current of chlorine gas, or it is mixed with about 1 per cent. of manganese dioxide and a sufficient quantity of hydrochloric acid, by which means chlorine is gen-

erated. By both of these methods the gold is converted into soluble auric chloride, from which the metal is recovered as a dark powder by precipitation with ferrous sulphate. When much silver is present common salt is employed to dissolve the chloride of silver formed, which would otherwise protect the gold from the action of the chlorine. The chlorine method is very accurate and yields a product of great purity.

When gold is extracted by amalgamation or by the lead process, it carries with it other metals to a certain extent with which it was associated in the ore; to free it from these it is subjected to further treatment. The base metals are gotten rid of by the process of *cupellation*. (See Silver.) The resulting alloy obtained by this process contains, besides gold, more or less silver, and sometimes metals of the platinum group. To separate gold from the silver with which it is alloyed it is subjected to the action of strong boiling sulphuric acid, which converts the silver into argentic sulphate; this is removed by hot water, in which it is freely soluble. The gold, being unacted upon, remains as a heavy black or brown powder, which after washing is melted and cast into ingots.

The operation which is termed *parting* is conducted as follows: The alloy of silver and gold, in which the former is in excess, is melted in plumbago crucibles, and cast in a thin stream into cold water from a considerable height, by which the alloy is obtained in a granulated or flaky condition; this is sometimes repeated several times to ensure uniformity of composition, as well as to expose a greatly increased surface of metal to the action of the acid. The granulated metal after being dried and weighed is boiled with twice its weight of concentrated sulphuric acid (sp. gr. 1.84): this part of the operation is conducted either in platinum alembics or in stills or in cast-iron pans; the former are employed where the alloy is rich in gold. On the large scale the vapors of sulphuric and sulphurous acid which are liberated in large quantity during the process are conveyed by a lead pipe into a leaden tank, where the sulphuric-acid vapors are at once condensed, while the sulphurous-acid gas passes on through a lead pipe from the top of this tank to a leaden chamber, where by a suitable oxidizing process they are reconverted into sulphuric acid, which is concentrated and used over again. The boiling is continued until all of the silver is converted into argentic sulphate, which forms a pasty mass of crystals; these are ladled out and thrown into a leaden tank containing water, which is boiled by passing steam from a boiler into it in jets through perforated lead pipes. The hot water dissolves the argentic sulphate and leaves the gold in a finely-divided state as a black powder at the bottom of the tank: this when it has accumulated in sufficient amount is collected, well washed, and dried. It still retains from one-thirtieth to one-fiftieth of its weight of silver. To remove the remaining portions of silver the gold is mixed with one-fourth its weight of dried sodium sulphate and an amount of strong sulphuric acid in the proportion of 3 parts of the acid to every 5 parts of sodium sulphate used. Heat is applied as long as any vapors of sulphuric acid escape. This is repeated a second time, but without driving off all the sulphuric acid. The mass is next boiled with sul-

phuric acid, when the gold alone is left, which is then melted with a little potassium nitrate and cast into an ingot.

The rationale of the acid-sodium-sulphate process is that the sulphuric acid in combination with the sodium sulphate can be raised to a higher temperature without vaporizing, which renders its solvent action on the silver more complete and thorough. Metallic silver is recovered from its sulphate formed in this process by leaving it in contact with copper plates or shavings, cupric sulphate being formed and metallic silver in a spongy state being liberated, which after being washed and dried is compressed into cakes, melted in plumbago crucibles, and cast into ingots. The process of parting by sulphuric acid, when properly conducted, is, besides being accurate, extremely economical, the sulphate of copper formed having a steady commercial demand, or when this falls off the copper is recovered by reduction with scrap iron. 1 part of gold in 2000 of silver can be profitably extracted by this process.

The presence of copper is not detrimental in the alloys treated by this process if it does not exceed 75 parts in 1000; should the amount of copper exceed this, the alloy is either cupelled with lead or melted with more silver to bring the amount of copper within the proper limit. The alloy should also be free from lead and tin, which are apt to melt upon the bottoms of the platinum vessels used and injure them seriously. The alloy must not contain more than one-fifth its weight of gold, otherwise it is unaffected by the acid.

Gold can also be separated from silver by means of nitric acid, the latter metal being converted into a nitrate, which is readily soluble in water. It is necessary, however, that the nitric acid used should be free from any contamination by chlorine, which would cause a precipitation of part of the silver as chloride. The nitric acid should therefore be tested by adding to a portion of it a few drops of solution of argentic nitrate, when if any chlorine or its compounds be present a milky turbidity will at once take place, owing to the precipitation of the insoluble argentic chloride formed.

An alloy containing more than 1 part of gold to 3 parts of silver is very little affected by nitric acid, so that with alloys rich in gold it is necessary to reduce them by the addition of metallic silver until about the above-named proportions are reached. From this necessity of making the alloy of four parts, 1 quarter gold to 3 quarters silver, arose the term *inquartation* or *quartation* used in connection with this process. The granulated alloy is heated with twice its weight of moderately strong nitric acid (sp. gr. 1.32) in a still of platinum or glass connected with a suitable apparatus for condensing the vapors which are evolved. Fresh acid is added from time to time, and the process is continued until the red fumes which were at first formed cease to rise; this marks the termination of the action of the acid upon the silver. The still is then allowed to cool, the solution of argentic nitrate is drawn off, and the undissolved gold treated with a little more nitric acid to free it of any remaining portions of silver. It is then washed with water, dried, melted, and cast into an ingot.

From the argentic nitrate formed in this process the metallic silver is recovered by first converting it into a chloride by the addition of hydro-

chloric acid. This throws down the argentic chloride as a white curdy precipitate, which after being washed with water is slightly acidulated with sulphuric acid and some bars or plates of zinc placed in it. The hydrogen evolved by the action of the acid on the zinc combines with the chlorine of the argentic chloride to form hydrochloric acid, which also acts upon the zinc, forming zinc chloride, which dissolves, leaving the silver in a finely-divided, spongy state. The zinc plates are taken out, and the spongy silver is washed with dilute sulphuric acid to remove any small particles of metallic zinc, after which it is washed with water, dried, melted, and cast into ingots.

The process of parting by sulphuric acid, in addition to greater economy, has the advantage of producing a finer grade of metal than the nitric-acid process, though the oxidizing action of the nitric acid in the latter process is of especial utility where tin or antimony is present in the gold.

Besides the metals already mentioned as commonly found associated or alloyed with gold, that from California is often contaminated with small grains of an extremely hard alloy of osmium and iridium, which on account of its great hardness causes considerable damage to the dies when the metal is coined, as the osm-iridium alloy is unchanged during the melting and casting of the gold. The removal of the osm-iridium alloy is effected by melting the gold with three times its weight of silver, which lowers its specific gravity and allows the osm-iridium, which is of high specific gravity (21.1) and very infusible, to settle to the bottom of the crucible. The greater part of the melted metal is ladled out, leaving the rest very rich in osm-iridium at the bottom. This is repeatedly melted with silver, which still further diminishes the proportion of gold, and ultimately the mixture of osm-iridium with silver and a little gold is boiled with sulphuric acid, which removes the silver, leaving the osm-iridium mixed with some powdered gold, which is removed by washing.

The presence of small quantities of lead, arsenic, or antimony, which occur in Australian gold, renders the metal very brittle. These metals are sometimes eliminated by throwing a small quantity of mercuric chloride (corrosive sublimate) into the melted metal; this salt decomposes under these conditions, its chlorine uniting with the base metals present to form chlorides, which are volatilized together with the liberated mercury.

F. B. Miller of Sydney has devised a process which is in successful use for refining gold by forcing into the molten metal a current of chlorine gas through a clay tube. All the silver present is converted into argentic chloride, which fuses and floats upon the surface of the molten metal, whilst any antimony, arsenic, lead, bismuth, or zinc is also converted into chloride and volatilized. The silver is afterward readily extracted from its chloride. The purification of gold by this method is known to be complete when orange-colored fumes begin to rise, and the action of the chlorine must be discontinued at this point, otherwise combination of the gold with chlorine takes place. It is stated that gold from 944 to 1000 fine can be produced by this method at less cost and much more expeditiously than by the humid processes, the time

required to part 300 ounces in one furnace being about two hours, at an average cost of four cents per ounce.[1]

Preparation of Chemically Pure Gold.—The methods previously described yield a metal which is more or less contaminated with small quantities of other metals: these produce marked variations in its physical properties, which are particularly noticeable when the gold is used in the form of foil as a filling material in the treatment of carious teeth.

Several methods are employed for the production of gold which is 1000 fine, or, as it is termed by the mints, absolute gold. It has been heretofore stated that a great variety of substances are capable of decomposing the auric chloride and liberating the metal. Among these may be noted carbon, phosphorus, sulphur, selenium, a majority of the metals, sulphurous anhydride, the chlorides and hydrogen compounds of antimony and arsenic, hydrogen peroxide, the protosalts of iron, and a large number of organic compounds, notably oxalic acid, gallic acid, gum arabic, sugar, and glycerin. Auric chloride is also easily decomposed by a weak galvanic current.

For the preparation of absolute gold, coin gold or the ordinary mint bars after being rolled down are treated with aqua regia in a glass flask by the aid of a gentle heat on a sand-bath. The aqua regia for this purpose may consist of 2 parts hydrochloric acid and 1 part nitric, and should be added at intervals in small portions at a time until solution of the metal is complete. The application of heat should not be made until near the end of the operation. Instead of previously mixing the acids, the hydrochloric acid may first be poured over the metal, and the nitric acid afterward gradually added in small portions, the function of the nitric acid being to oxidize the hydrogen of the hydrochloric acid, converting it into water, while chlorine, which is the active solvent, is liberated in the nascent state and unites with the gold, converting it into auric chloride, which dissolves.

When solution of the metal is effected, it must be evaporated to dryness or until all excess of acid is driven off, care being taken not to overheat and thereby decompose the salt. The auric chloride is now dissolved in a large amount of distilled water and allowed to stand for several days, until all of the silver originally present as an alloy in the gold separates and falls to the bottom of the vessel as chloride. From this it is separated by filtration: the solution may still contain copper, iron, platinum, and other metals. The gold may be separated from these by adding a clear and pure solution of ferrous sulphate until a precipitate ceases to form. After it has fully subsided the supernatant solution is to be removed by decantation or with a siphon, and the precipitated gold thoroughly washed with distilled water, and then digested with hot concentrated hydrochloric acid to remove any trace of iron or copper. The necessity for this becomes evident from the fact that precipitated gold, obtained by the use of ferrous sulphate, and which has been thoroughly washed with water, yields a distinct trace of iron to the hydrochloric acid used in the after-treatment: the color of the precipitated gold is also much lighter after digesting it with hydrochloric acid.

[1] *Dental Metallurgy*, Essig.

After carefully washing with distilled water to remove all trace of hydrochloric acid, the precipitated gold is dried and fused in a perfectly new borax-lined crucible with a little potassium nitrate, and cast into an ingot mould of clay, soapstone, or iron. When an iron ingot mould is used the resulting ingot should be treated with hot hydrochloric acid to dissolve any adhering particles of iron or ferric oxide which might contaminate it. The proof gold prepared at the United States Mint at Philadelphia is cast in iron ingot-moulds, and in the opinion of Mr. Eckfeldt, the chief assayer, it suffers no contamination from the iron ingot mould when subsequently treated with hydrochloric acid. The precipitant used is ferrous sulphate, and with the proper precautions the mint continually produces proof gold of 1000 fineness which is used for making check assays in the cupellation of gold alloys of unknown fineness.

The precipitation of gold from its chloride by ferrous sulphate takes place according to the following equation:

$$2AuCl_3 + 6FeSO_4 = Fe_2Cl_6 + 2Fe_2(SO_4)_3 + 2Au.$$

When oxalic acid and similar organic substances are used for the precipitation of gold, any platinum which may be present in the original solution should first be removed: this is accomplished by evaporating it to dryness upon a water-bath and dissolving the mass of crystals obtained in alcohol, after which a concentrated solution of potassium chloride is added, which throws down the double chloride of potassium and platinum as a bright-yellow precipitate, which is separated by filtration; after which silver is removed by largely diluting the solution, allowing it to stand several days for the silver chloride to subside, and again filtering as before, when it will be in a condition suitable for treatment with oxalic acid.

M. Pratt of Bordeaux and Mr. Jackson both recommend the following procedure: Sufficient potassium carbonate is added to convert all the auric chloride into potassium aurate; the solution is then filtered, and oxalic acid is added in excess. The solution is then to be rapidly heated to the boiling-point, when all the gold will subside in a chemically pure state as a yellow spongy mass. For the best results the original solution should contain at least 10 per cent. of auric chloride.

The addition of potassium carbonate to the auric chloride solution prevents the precipitation of copper, with which it forms a carbonate, which in the presence of oxalic acid is converted into a soluble double oxalate of copper and potassium, and remains dissolved. When copper is thrown down as oxalate along with the pure gold obtained by acting upon a solution of auric chloride by means of oxalic acid, its removal is effected by boiling the precipitate with a concentrated solution of potassium carbonate, the double oxalate of copper and potassium being formed as before. Failure in the observance of this almost necessarily results in the contamination of the gold with copper.

The reaction which takes place between auric chloride and oxalic acid in the foregoing operation is represented by the following equation:

$$2AuCl_3 + 3C_2H_2O_4 = 6HCl + 6CO_2 + 2Au.$$

Gold may be precipitated from its acid solution in a state of purity in the form of brilliant spangles by means of hydrogen peroxide; thus:

$$2AuCl_3 + 3H_2O_2 = 6HCl + 6O + 2Au.$$

Strong solutions of sugar or gum arabic decompose auric chloride, with liberation of the metal in the form of arborescent masses which consist of aggregations of the normal isometric crystals of gold. The decomposition takes place slowly unless aided by heat. The chemical reaction involved is analogous to that which takes place between auric chloride and oxalic acid.

Sulphurous acid precipitates pure gold from the solution of its chloride in the form of a metallic powder made up of minute scales, which do not cohere under pressure, owing, no doubt, to the absorption of a portion of the sulphurous acid by the metal. The precipitated metal should therefore be fused with borax and nitre and cast into an ingot, which will, upon being beaten out into foil, furnish gold suitable for filling.

The sulphurous acid which may be generated by the action of sulphuric acid upon copper, mercury, or carbon in a glass flask should be carefully washed by passing it through a wash-bottle before it is conducted into the auric-chloride solution. The reaction takes place as follows:

$$2AuCl_3 + 3H_2O + 3H_2SO_3 = 6HCl + 3H_2SO_4 + 2Au.$$

Auric chloride may also be decomposed by the galvanic current, and the metal liberated in a variety of forms, dependent upon the strength of the current, the strength and temperature of the solution, etc. The preparation known as Watt's crystal gold is prepared by electrolysis. The metal is deposited upon a platinum electrode suspended in a solution of auric chloride. The anode consists of a plate of pure gold, which is dissolved during the process in exact proportion to the amount of gold deposited upon the platinum negative pole or cathode. By proper regulation of the current, temperature, etc., large or small crystals may be produced or the metal may be deposited as a coherent film.

It has already been stated that owing to the weakness of the affinity existing between gold and chlorine the auric chloride is decomposable by a large number of substances: so weak is this affinity that sunlight alone may break up the compound when it exists in a perfectly neutral condition in a solution exposed to the air. The presence of a slight excess of hydrochloric acid, however, protects it from spontaneous decomposition.

Pure gold, no matter what method of precipitation has been employed, when intended for the manufacture of dental foil should be fused in a perfectly new crucible with borax and nitre to free it from any possible traces of oxidizable metals, and then cast in a warm ingot-mould, which if of iron should be oiled or smoked. It is highly probable that a tougher ingot and one which would laminate better would be obtained by casting the gold into an ingot-mould of gas carbon which had been brought to a red heat just previous to casting the metal in it, and allowing the whole to cool gradually. By this means a normal polarization

of the molecules of gold would be more nearly secured and the highest degree of softness and ductility attained.

Gold-Beating.—The process of reducing the ingot of pure gold to the thin sheets of foil used in filling teeth is thus described by a practical gold-beater:[1]

"The gold is melted in a crucible at a higher temperature than is necessary simply to fuse it, by which its malleability is improved. It is then poured into moulds previously heated and slightly oiled on the inside, and cast into flat oblong ingots, each about an inch wide, one-fourth of an inch thick, and four, six, or eight inches in length. The ingots are then taken from the moulds and annealed, and to clean them they are plunged into a weak solution of sulphuric acid. When the ingot is cold the French gold-beaters hammer it out to the thickness of one-sixth of an inch, and expose it at the same time to repeated annealings, but this operation (termed forging) is omitted in the United States and England. The next process is lamination, which consists in repeatedly passing the ingot between two polished steel rollers, gradually brought closer together, until it is formed into a ribbon of one inch in width and of the required thickness, the length depending upon the number of ounces of gold in the ingot. The gold is annealed after each lamination. The next operation is the beating. The ribbon is carefully divided with a pair of compasses, and cut up in pieces the size of an inch square, each weighing from 5 to 35 grains; about two hundred or two hundred and fifty of these are placed, by means of wooden pincers, between the leaves of a cutch, which formerly consisted of a packet of fine calf-skin vellum, but it is now usual to employ a tough paper manufactured in France called French paper. A case of strong parchment or vellum, open at both ends, is drawn over the cutch, and this is enclosed by another of the same kind drawn over it at right angles to the first, so as to cover the edges which the first had left exposed. The cutch is then beaten with a twelve- to sixteen-pound hammer upon a smooth block of hard marble supported on a strong bench or post and surrounded on three sides by a wooden ledge, the front being left open, with a leathern apron attached to it, to preserve any gold that may fall from the packet in the process of beating. The hammer is short-handled, and is wielded by the beater with one hand while with the other the packet is continually rotated and turned over to distribute the force equally. The elasticity of the packet causes the hammer to rebound and lightens the labor of the operator.

"At intervals the packet is taken up and bent or rolled between the hands to overcome any slight adhesion between the leaves and the interposed paper, or it is taken to pieces to examine its state and to shift the central leaves to the outside, and *vice versâ.*

"When the gold plates of an inch square are beaten out into about three and a half inches square, or to nearly the size of the leaves of the cutch, which generally requires about twenty minutes' beating, the packet is opened, and each leaf of gold is taken out and put into another packet made of the same material, but larger than the first. The shoder, as it is called, is enclosed in parchment or vellum as before,

[1] W. H. Eakins.

and beaten till the squares of gold are about the size of the skin, which requires about thirty minutes' beating for the operation. During this period the packet must be often folded to render the gold as loose as possible between the leaves of the paper. After the last beating the leaves are lifted one by one by a pair of long pincers made of white or box wood, and the gold is spread out on a leathern cushion. Broken and blemished leaves are rejected. The good ones have the ragged edges cut off with a square frame of sharp cane called a wagon, which reduces them to a uniform size. Afterward each sheet is annealed and placed between the leaves of a book which has been previously weighed. The amount of gold by weight which it contains is then easily obtained by deducting the weight of the empty book from its weight when filled. The numbers of foil indicate the weight of the leaf. No. 4 contains four grains; No. 6, six grains; No. 10, ten grains to the leaf, etc. To find the number of sheets in a book, divide the number of foil by the number of grains in the book, which is sixty, or two and a half pennyweights, or one-eighth of an ounce."

Physical Properties of Gold-Foil.—As finally prepared for the uses of the dentist, gold-foil presents a variety of physical properties, many of which differ so widely in the productions of various manufacturers that entirely distinct methods of manipulation are necessary for its successful introduction in the operation of filling teeth.

Two general classes of gold-foil are recognized—cohesive foil, which is distinguished by the property of perfectly welding to itself without the aid of heat by simple pressure; and non-cohesive foil, which is devoid of this property. Pure or absolute gold inherently possesses the quality of cohesiveness to the extent which makes cold welding possible by virtue of the purity of its surface. Non-cohesive gold-foil is devoid of this property, because in a chemical sense its surface is impure. Cohesiveness is a quality which does not belong to gold alone, but is shared in common by a number, perhaps most, of the metals, and is readily demonstrable when the proper precautions are observed to secure pure surfaces of contact. Thus, two freshly-cut surfaces of lead when at once pressed together cohere firmly, but if contact is not made until after the lapse of several minutes a slight superficial oxidation occurs which is sufficient to prevent molecular contact, and cohesion becomes impossible. Freshly-reduced copper in an atmosphere of hydrogen may also be welded into a compact mass. Whatever interferes with the surface purity of gold either diminishes or completely destroys its cohesive property.

The terms "hard" and "soft" have been largely used to designate cohesive and non-cohesive gold-foil respectively: such use is, however, erroneous and unwarranted by the actual facts involved, as the relative qualities of hardness and softness exhibited in dental gold-foils of the cohesive and non-cohesive types are rather apparent than real. The feeling of softness exhibited by non-cohesive foil under the instrument is due largely to the fact of its non-cohesiveness, whereby the several laminæ slip or slide one upon another, thus conveying a yielding or soft sensation to the tactile sense, and making it possible to condense large masses at a time, the pressure being conveyed continuously throughout

the mass and the condensation or consolidation being uniform. A similar mass of cohesive foil, treated in the same manner and under like conditions, presents a greater resistance to the instrument, and conveys the idea of hardness, from the fact that as pressure is applied the successive laminæ unite or weld together from the surface downward into a homogeneous stratum of metal which offers greater resistance and becomes more impenetrable by constant additions to its thickness, until the condensing instrument fails to make any further impression; but upon removing the mass of gold it will be found that that portion of it which occupied the bottom of the cavity is still in the form of foil and not homogeneously condensed. This difference in the working qualities of cohesive and non-cohesive foils has necessitated entirely distinct methods of operating with them.

The cohesive quality is developed in pure gold-foil by annealing, and, as a matter of fact, it is rendered softer thereby in precisely the same manner that an ingot of pure gold which has become hard and almost brittle by hammering or rolling has its softness restored by subjecting it to a red heat. Hardness—or, as variously termed, "harshness" and "brittleness"—in dental foils depends upon several causes: these are physical, or those dependent upon the mechanical treatment of the metal and the methods employed in its fusion, annealing, etc.; and chemical, by which the purity of the product is modified or lessened.

It is not within the scope of this section to discuss the merits of certain foils having distinctive physical properties, nor the adaptability of these to particular methods of operating, but only as to what causes the well-known variations in dental foils may be attributed. Given absolute gold and perfect exclusion of all sources of contamination during the process of making it into foil, there is probably but one stage of the process of its manufacture that exerts any marked influence upon its physical properties other than the beating or laminating process; and that is the process of casting it into the ingot previous to passing it through the rolling-mill.

It has been observed in many other pure metals that when two ingots are cast, one in a chill mould and the other in a heated mould, and gradually cooled, the latter possesses properties differing greatly from the former, it being generally tougher and softer; and this is also true of gold, the explanation being that the molecules of metal when very gradually cooled from the state of fusion arrange themselves in a state of normal polarization, whereas when suddenly chilled the metal is solidified with its molecules in a state of strain, and is therefore more brittle, harder, and lacking in toughness. The normal arrangement of molecules is to a certain extent restored by annealing for some time at a red heat, which by increasing the intermolecular distances permits of their rearrangement in something approaching normal order. The effect produced by annealing is not so marked, however, as that obtained by remelting and slowly cooling. It would seem desirable, on theoretical grounds at least, to cast gold from which dental foil is to be manufactured in a thick-walled ingot-mould made of gas carbon which has been heated to near the fusing-point of the metal previous to

casting, and allowing it to cool very gradually, and when fully cold to roll the ingot in but one direction.

Lack of purity is the most potent factor in the modification of physical properties observed in gold-foils. The contamination may be due to imperfect methods of refining, to carelessness in the use of the methods employed, or to the introduction of contaminating matters during the process of converting the refined ingot into foil. The slightest admixture of other metals, particularly those which are oxidizable, seriously affects those qualities for which gold stands pre-eminent and make it particularly desirable as a filling material. Copper, iron, tin, lead, arsenic, antimony, and bismuth have already been alluded to as detrimental to the softness and cohesiveness of gold: their injurious effect is especially evident in dental foil, rendering it worthless.

The following assays, made for the author, and for which he is indebted to Mr. Patterson DuBois and Mr. Jacob B. Eckfeldt, assayers at the United States Mint, Philadelphia, exhibit in thousandths the relative fineness of some of the foils in general use. The samples for assaying were all purchased in the open market and subjected to exactly similar treatment—viz. heating to bright redness, cooling, and weighing. The assays were made in duplicate:

No. 1, Abbey's Non-cohesive	998.8	998.7
" 2, Wolrab's, from C. A. Timme	999.2	999.3
" 3, Quarter Century, S. S. White Dental Mfg. Co.	999.1	999.1
" 4, Rowan's Decimal Foil, from Gideon Sibley	999.9	999.8

In addition to the foregoing, a sample of the proof gold prepared at the Philadelphia Mint, and known to be absolute gold, or 1000 fine, after being beaten into foil the thickness of No. 4 dental foil was assayed to see if any non-volatile impurity was taken up during the beating process. The result of the assay showed no appreciable variation from the original fineness. The foil produced from the proof gold of the mint was notably soft and tough, annealing at a red heat, developed a maximum amount of cohesiveness in it, and, so far as a limited number of practical tests of it made by several expert dental operators could demonstrate, it was in all respects fully equal to the "soft cohesive" foil of Wolrab.

In a paper by Dr. C. A. Timme, read before the New Jersey State Dental Society,[1] on "The Properties and Qualities of Different Makes of Gold used for Filling Teeth," the following analyses, made by Dr. Stillman of the Stevens Institute of Technology, Hoboken, N. J., are reported:

No. 1, sample, S. S. White, 999. fine.
" 2, " Wm. Valleau, N. Y., 998.7 fine, traces of copper and aluminum.
" 3, " Ed. Rowan, N. Y., 999. fine, traces of lead and silver.
" 4, " E. Kearsing, Brooklyn, 998.4 fine, small amount of lead was found.
" 5, " R. S. Williams, N. Y., 999. fine, traces of platinum found.
" 6, " Wolrab's, 999.8 fine, no traces of any other metals present.

Following the paper of Dr. Timme an analysis of Wolrab's foil, which was made by Prof. C. F. Chandler of Columbia College, N. Y.,

[1] *Transactions New Jersey State Dental Society*, 1886, p. 162.

was reported by Mr. M. M. Johnson, in which traces of iron and silver, with some organic matter, were shown.

The foregoing analytical results possess considerable interest as showing the near approach to absolute purity that has been attained in a number of well-known brands of dental gold-foil.[1] They fail, however, in one point of prime importance—viz. in stating accurately the amount and nature of the impurity in each instance. These data can only be obtained by an elaborate and expensive analytical investigation, which, owing to the limited time at command, could not be carried out in the case of the samples assayed at the Philadelphia Mint.

While the departure from absolute purity in most of the samples assayed is but slight, and would make but an inappreciable difference in the physical qualities of the resulting foil where the nature of the impurity was such as to be practically inert, yet it is equally certain if such elements as lead, iron, arsenic, bismuth, tin, antimony, etc. constituted the impurity, that the physical qualities of gold-foil so contaminated would be greatly modified, if not rendered unworkable, even should the impurity exist to so small a fraction as shown in the analyses cited. For example, one of the foils assayed showed a fineness but a trifle above 998, leaving two thousandths of the mass as impurity, or, in other words, one-fifth of 1 per cent. The same percentage of phosphorus or sulphur in steel would render it worthless for most purposes, or a variation of that amount in the combined carbon of the same metal would largely determine its commercial and economic value. It is stated by Harris and others that one part of lead in two thousand parts of gold entirely destroys its cohesiveness and renders it brittle and unworkable. A foil contaminated to this amount would still be 999.5 fine, which is fully equal to the fineness of many standard makes of dental foil.

The most commonly occurring impurities, perhaps, in dental foils are lead, iron, silver, and platinum, the first resulting from imperfect cupellation, leaving traces of lead, which, though it may not be sufficient to cause marked brittleness, at least impairs the toughness and kid-like quality which should belong to the product. Dental gold frequently contains iron as a contaminating element, which may have been introduced by contact with an iron ingot-mould or by the rolling-mill during the process of manufacture; but the presence of this metal in some brands of dental foil is undoubtedly due to carelessness or ignorance in the preparation and subsequent treatment of the precipitate of gold from the solution of its chloride by ferrous sulphate; for unless the precipitate so obtained, in addition to thorough washing, is digested for some time with hydrochloric or sulphuric acid, traces of iron are almost certain to remain with it, which subsequent fluxing with potassic nitrate will ordinarily fail to eliminate. A series of tests upon this point made by the writer affords ample confirmation of this.

[1] The assayer of the U. S. Mint, Philadelphia, stated to the author that he issued at one time a certificate to Messrs. Johnson Bros. of New York certifying to the absolute purity of their "1000-fine" dental gold-foil, which was the only instance of the kind which had occurred in their experience in assaying dental foils. This certificate was issued upon the assay of but one sample, and he was of course unable to say whether the standard of absolute purity exhibited by it has since been maintained.

Just what effect the presence of iron in dental gold produces upon its physical qualities has not been fully demonstrated: there is reasonable ground for the belief that many cases of discoloration observed upon the surfaces of gold fillings originate from the combined or alloyed iron in the gold, and not from such iron as might be mechanically rubbed off from the packing instrument; which no doubt always takes place, as is abundantly shown by a carefully-conducted series of experiments made by Dr. William H. Rollins, in conjunction with Dr. Hills of the Harvard Medical School, a full account of which was published in the *Boston Medical and Surgical Journal.* Iron in small amounts, while not interfering with the softness of gold to a marked extent, probably lessens its cohesiveness; and such investigation as the writer has been able to make tends to confirmation of the idea that iron in some form is the material used by some makers of non-cohesive foil to destroy the cohesive quality of the metal.

Silver and platinum, when present in gold-foil as mere traces, probably exert but slight detrimental influence upon it. The former metal is almost invariably present in all the samples examined, and results from imperfections in the parting process. Experience has shown that the slight amounts generally present are not appreciable in the ordinary manipulations of the foil during the filling operation. The occurrence of traces of platinum is probably rare, though when present to any considerable extent its effect would be to increase hardness and brittleness without markedly affecting cohesiveness.

Copper, even in small quantities, diminishes cohesion, and, according to the investigations of Dr. J. P. H. Brown,[1] a dental foil containing copper cannot be made cohesive by annealing.

The *rationale* of the action of oxidizable metals when alloyed with gold is, in all probability, that the oxidation of the molecules of the alloying metal upon the surface of the foil prevents cohesive contact by interposing an extremely attenuated film of oxide.

The substances which exert a modifying influence upon the physical qualities of gold-foil so far considered have been in the nature of fixed or non-volatile impurities, which constitute an integral component part of the metal itself. It remains yet to consider some important modifications in the physical properties of dental gold-foil which result from the imbibition or occlusion of gases and various volatile substances by the foil when exposed to their influence.

It has long been observed that cohesive gold-foil in a short time loses its welding property unless especial precautions are taken to protect it from atmospheric action, and that under certain conditions its cohesiveness was rapidly lost, but was readily restored by annealing at a red heat. Prof. G. V. Black, in a paper read before the New York Odontological Society,[2] has presented the most satisfactory and elaborate research upon the subject which has yet been given to the profession. He found that gold-foil possessed the power in common with platinum and some other metals of condensing or occluding gases and volatile substances upon its surface—that when such gaseous occlusion took place the welding property was entirely destroyed. The non-cohesive

[1] *Dental Times,* vol. i. p. 68. [2] *Dental Cosmos,* vol. xvii. p. 138.

property was produced not only by the gases and moisture of the atmosphere, but also by hydrogen sulphide, the phosphorus compounds of hydrogen, chlorine, sulphurous anhydride, ammonia, etc. See Vol. II. p. 96. In view of the readiness with which gold-foil absorbs gases, it is of importance that certain precautions be observed in annealing it. The best results are obtained by placing a sheet of unfolded foil upon a sheet of mica or thin platinum, and using a large flame, so that the heating may be uniform.

The use of a naked flame for annealing gold-foil is objectionable, for the reason that the foil is subjected to the action of the products of combustion, which in the case of a Bunsen burner contain, besides the usual water and carbonic acid gas, a greater or less amount of sulphurous anhydride; and should the perfection of the combustion be in any way modified, acetylene and other deleterious hydrocarbons are produced. Where a naked flame is used for annealing, the flame produced by the combustion of rectified 95 per cent. alcohol, burned from an asbestos wick, is the least objectionable.

Alloys of Gold.—Gold easily unites with most of the metals to form alloys, and the qualities conferred upon the precious metal by such additions are exceedingly varied. In its pure state gold is too soft for most purposes for which it is employed, and it becomes necessary to increase its hardness and toughness by adding proper quantities of other metals to improve its physical properties for special purposes. Most important among the metals used for debasing the fineness of gold are copper and silver, as by the addition of one or both of these metals a gold alloy may be obtained suitable for almost any purpose for which gold is used in the arts—viz. coinage or articles of adornment and ornamentation.

Copper increases the hardness of gold without correspondingly diminishing its malleability, and at the same time improves its toughness. Copper, however, produces a marked effect upon the color of gold, imparting to it a decidedly reddish tint, which is not the case when silver is used or when the debasing metal consists of an alloy of copper and silver. The affinity between copper and gold appears to be greater than that existing between gold and silver, as alloys of the latter metals show a greater tendency to segregation upon cooling from a molten condition than do those of copper and gold; indeed, there is good reason to believe that copper and gold when combined in about the proportions of 76 per cent. of gold and 24 per cent. of copper unite to form a definite chemical compound, such an alloy being distinctly crystalline in texture and quite brittle. The addition of a larger proportion of either metal to this alloy diminishes its brittleness and restores its malleability.

Silver when added to gold increases its hardness and toughness in the same manner that copper does, and the metals mix freely in all proportions, though in order to ensure homogeneity of the resulting alloy the mixture should be remelted and cast several times. Gold when alloyed with silver rapidly loses its rich yellow color, becoming paler, until, when the proportion of silver in the alloy amounts to about 70 per cent., the resulting compound has a distinct greenish color, and is used by jew-

ellers for the manufacture of certain kinds of ornaments. Gold when found native is always alloyed with silver, the proportions of the latter metal being extremely variable.

Gold for coinage is alloyed with either copper or silver or an alloy of both the latter metals. The amount of alloy used varies in different countries, but in each case is prescribed by law. The standard alloy for American, German, and French gold coins consists, in 1000 parts, of 900 parts of pure gold and 100 parts of copper. The gold coins of Great Britain are of the uniform fineness of 915.5, but below the legal standard about one-thousandth;[1] the alloy is copper. The first gold coins made in England were made of pure gold, and were introduced by Henry III. in 1257. In America the first gold coins made were the eagles or ten-dollar pieces, coined at the first United States mint in Philadelphia in 1795, during the administration of Washington: they were 22 carats fine and weighed 270 grains. In 1834 the weight of these coins was changed to 258 grains and the fineness to 899.225; and again, in 1837, the fineness was changed to 900 fine, which is the present standard, the alloy being copper. The older gold pieces of the United States coinage were reduced to standard by an alloy of 2.5 parts of silver and 7.5 parts of copper, which maintained the yellow color of the gold better than when pure copper was used to reduce the gold to standard fineness. Gold reduced to standard by copper is found to contain a small amount of cuprous oxide, which results from oxidation of the alloy and subsequent solution of the cuprous oxide in the molten metal.

The following alloys are used in the manufacture of jewelry:

18-carat Gold of Yellow Tint.

Pure gold	15 dwt.	
" silver	2 "	18 grains.
" copper	2 "	6 "

18-carat Gold of Red Tint.

Pure gold	15 dwt.	
" silver	1 "	18 grains.
" copper	3 "	6 "

16-carat Spring Gold.

Pure gold	1 oz. 16 dwt.
" silver	6 "
" copper	12 "

16-carat Gold of Yellow Tint.

Pure gold	1 oz.
" silver	7 dwt.
" copper	5 "

16-carat Gold of Red Tint.

Pure gold	1 oz.
" silver	2 dwt.
" copper	8 "

The following colored gold alloys are used in the production of certain kinds of jewelry and ornaments:

Full Red Gold Alloy.

Gold	5 dwt.
Copper	5 "

Red Gold.

Gold	10 dwt.
Silver	1 "
Copper	4 "

Green Gold.

Gold	5 dwt.
Silver	21 grains.

Gray Gold.

Gold	3 dwt.	15 grains.
Silver	1 "	9 "

[1] Eckfeldt on *Coins.*

Blue Gold.

Gold	5 dwt.
Steel filings	5 "

Antique Gold of Fine Greenish-yellow Color.

Gold	18 dwt. 9 grains.
Silver	21 "
Copper	18 "

Jeweller's Solder for 18-carat Gold.

18-carat gold	1 dwt.
Silver	2 grains.
Copper	1 grain.

Solder for 16-carat Gold.

16-carat gold	1 dwt.
Silver	10 grains.
Copper	8 "

Jeweller's solders are usually made from the gold upon which they are to be used by the addition of small quantities of copper and silver. The addition of about 4 grains of brass to the pennyweight of gold solders greatly increases their fusibility and flowing quality under the blowpipe flame.

Gold alloys intended for use in the mouth as a base for artificial dentures must, in order to give efficient service, be sufficiently rigid to resist the strain to which they are subjected in mastication, and must not be debased with copper to an extent which renders them liable to be acted upon by the oral fluids or food. In general, it is safe to use no gold of a fineness lower than 18 carats, but even in this grade much depends upon the character of the alloy, as it frequently occurs that individuals will complain of a metallic taste about a plate made from 18-carat gold, which can only be remedied by using a higher grade or one in which copper, or at least a portion of it, is replaced by silver and platinum as the alloy.

The writer was upon one occasion compelled to make a 20-carat gold alloy, using fine silver and pure platinum to reduce the carat of the gold, for a patient who could not tolerate even a 20-carat plate which contained copper: her repugnance amounted to an idiosyncrasy, but was certainly not assumed, as this point was carefully tested with four different plates. The metallic or coppery taste was developed in about twenty-four hours to such an extent that it became intolerable to her. The 20-carat alloy containing no copper was made into a plate which was worn with entire satisfaction.

Gold plate finer than 18 carats, when alloyed only with copper and silver, must necessarily be used thicker or be strengthened by soldering two thin plates together, as by reason of its softness it is liable to bend out of shape during the process of mastication. The higher grades of gold may be made sufficiently rigid by a slight admixture of platinum without seriously interfering with their color; and such alloys are decidedly preferable, from the fact that they can be made much lighter, and they possess a degree of rigidity and elasticity which plates made from the higher grades, 20- or 21-carat gold, do not approach. It is stated by Mr. Thomas Fletcher[1] that gold plate containing platinum "has not the permanence and resistance to acids shown by the ordinary alloy commonly used in England;" but, so far as can be ascertained, there is no evidence that the addition of platinum in small amounts to the alloys used for dental plates in any way deteriorates them or interferes with their integrity or wearing qualities.

[1] *Dental Metallurgy*, Fletcher, p. 38.

The following formulæ may be used for the formation of alloys suitable for the construction of plates, etc. for the mouth:

No. 1, 18-carat Gold Plate (Johnson Bro.'s Formula).

United States gold coin	64½ dwt. ($60).
Pure silver	13 "

This formula gives an alloy slightly above 18 carats fineness.

No. 2, 18-carat Plate.

Gold	18 dwt.
Silver	2 "
Copper	4 "

No. 3, 18-carat Plate.

Gold coin	20 dwt.
Silver	2 "
Copper	2 "

No. 4, 19-carat Plate.

Gold	19 dwt.
Silver	2 "
Copper	3 "

No. 5, 19-carat Plate.

Gold coin	20 dwt.
Silver	40 + grs.
Copper	25 "

No. 6, 20-carat Plate.

Gold	20 dwt.
Silver	2 "
Copper	2 "

No. 7, 20-carat Plate.

Gold coin	20 dwt.
Silver	20 + grs.
Copper	18 "

No. 8, 21-carat Plate.

Gold	21 dwt.
Silver	1 "
Copper	2 "

No. 9, 21-carat Plate.

Gold coin	20 dwt.
Silver	13 + grs.

No. 10, 21-carat Plate.

Gold coin	20 dwt.
Copper	6 grs.
Platinum	$7\frac{5}{7}$ "

No. 11, 22-carat Plate.

Gold	22 dwt.
Silver	18 grs. —
Copper	1 dwt.
Platinum	6 grs.

The formulas of the above alloys, with the exception of No 1, are taken from Richardson's *Mechanical Dentistry*, and are all made of pure metals unless otherwise indicated.

Prof. Harris recommends the following formulas for the production of alloys of 20-carat fineness suitable for clasps, backings, or where great strength and elasticity are desired:

No. 12.

Pure gold	20 dwt.
" copper	2 "
" silver	1 "
" platinum	1 "

No. 13.

Coin gold	20 dwt.
Pure copper	8 grs.
" silver	10 "
" platinum	20 "

Many of the older dentists, who were accustomed to manufacture their own alloys for gold plate, etc., simply pursued the method of reducing United States coin to the required carat by the addition of fine silver, by which means plates were produced which left nothing to be desired as to strength, color, or texture, as well as permanence. Formula No. 1, for 18-carat gold plate, is made in this manner. Where plates of 20-carat gold were produced by reducing coin gold to the 20-carat standard with fine silver, and the resulting alloy proved too soft, additional rigidity was obtained by the addition of a few grains of platinum to the pennyweight of alloy.

The rigidity of the platinized gold alloys renders their adaptation to the die difficult by the ordinary method of swaging unless the zinc

counter-die is used, in which case no trouble is experienced and the adaptation is rendered perfect: the same holds true of the rigid alloys of platinum and iridium.

Prof. Harris states[1] that the alloy of platinum and gold has an increased affinity for oxygen when the two metals are united in certain proportions. "This effect is so marked that such an alloy is readily acted upon by nitric acid." This tendency of platinum when alloyed to promote oxidation is also observable in its alloys with iron and with silver; but it is questionable whether the small amount necessary to increase the rigidity of gold plate which has already been reduced to, say, 20-carat or even 18-carat standard by means of copper and silver, has any effect upon the permanency or integrity of such an alloy when used in the mouth as a base for an artificial denture.

Gold Alloys used in Dentistry as Solders.—Within certain limits the fusibility of alloys of gold with copper and silver is in direct proportion to the amount of base metal which is used to reduce the carat or fineness of the gold; therefore gold alloys of a given carat may be successfully soldered with a similar alloy of a somewhat lower carat in which the debasing alloy is the same, but present in larger amount than that in the higher-grade gold alloy.

The following formulas yield satisfactory solders for use in the manufacture of dental mechanism:

No. 1, 14 Carats Fine.

American gold coin	$10.
Pure silver	4 dwt.
" copper	2 "

No. 2, 14 Carats Fine.

American gold coin	16 dwt.
Pure copper	3 dwt. 18 grs.
" silver	5 "

No. 3, 14 Carats Fine (Johnson Bro.'s).

Pure silver	$2\frac{1}{2}$ dwt.
" copper	20 grs.
" zinc	35 "
18-carat gold plate (formula No. 1)	20 dwt.

No. 4, 15 Carats Fine.

Gold coin	6 dwt.
Silver	30 grs.
Copper	20 "
Brass	10 "

No. 5, 16 Carats Fine.

Pure gold	11 dwt.
" silver	3 " 6 grs.
" copper	2 " 6 "

No. 6, 16 + Carats Fine.

Pure gold	11 dwt. 12 grs.
" silver	3 "
" copper	1 " 12 "
" zinc	12 "

No. 7, 18 Carats Fine.

Gold coin	30 parts.
Silver	4 "
Copper	1 "
Brass	1 "

No. 8, 20 Carats Fine, for Crown and Bridge Work.

American gold coin (21.6 carats fine) ($10 piece)	258. grs.
Spelter solder	20.64 "

No. 9, 20 Carats Fine—Same Uses as No. 8.

Pure gold	5 dwt.
" copper	6 grs.
" silver	12 "
Spelter solder	6 "

The spelter solder used in formulas 8 and 9 is composed of equal parts copper and zinc. The latter metal, when added in small quantity, is a valuable constituent of alloys used for soldering gold and silver

[1] *Principles and Practice of Dentistry*, 1871, p. 522.

plate, and when used within certain limits no objection can be urged against it, as its presence exerts no detrimental effect whatever with respect to the permanence of the alloy, while it imparts to it some valuable qualities—viz. it reduces the fusing-point and improves the fluidity or flowing quality of the solder to a marked degree. When a gold plate, for example, is soldered with an alloy simply of a lower carat in which the debasing metals are the same as those contained in the plate to be soldered, or, in other words, where the only difference between the plate and solder is in the proportions of their constituents, and not in the kind of component metals, union of the edges or surfaces by means of such solder takes place by virtue of the greater fusibility of the latter, and its flowing quality is in the main dependent upon its degree of fusibility, together with the capillarity of the joint and the cleanliness of the surfaces to be united. The introduction of zinc, however, enhances the flowing quality of the solder by reason of the superior affinity which that metal has for the gold or silver plate, as the case may be, with which it is brought into contact during fusion, causing it to flow rapidly and smoothly before the blowpipe. An excess of zinc is to be guarded against, as it renders the solder brittle, and is apt to cause a pitted appearance to the soldered surface after solidification, due probably to volatilization of a portion of the metal during the operation. It is also stated by Prof. Harris[1] to impart a "brassy" taste to the solder, but this probably does not occur when minute portions only are added, as the use of zinc in both gold and silver solders appears to be general, and the question of a brassy or metallic taste from a gold plate properly made seldom if ever occurs.

The introduction of zinc is best accomplished by the use of brass which contains about 30 per cent. of zinc, and for this purpose only such brass is employed as has been rolled or drawn—viz. brass sheet or wire—as the composition is more likely to be uniform. In the foregoing formulæ for gold solders brass of the composition 70 per cent. copper and 30 per cent. zinc may be advantageously substituted for the proportion of pure copper directed to be introduced, by which procedure the improvement in flowing quality caused by zinc will be secured and will be easily recognized.

The following rules for alloying gold, which were embodied in a paper published by the late Prof. Elias Wildman,[2] are so comprehensive that they are quoted in full:

In commercial phraseology and by dentists and jewellers the quality of gold is generally designated by the term "carat." This term is used in this case to express the fineness, not weight. Thus 24-carat gold is perfectly pure gold; 23-carat gold contains 23 parts of gold and 1 part of alloy; and 18-carat gold, 18 of gold and 6 of alloy.

A more scientific method, the one adopted in our mints, is to rate the fineness of gold by expressing the proportions of gold in thousandths. Thus the standard of American gold (in 1837 and since) is $\frac{900}{1000}$; meaning that in every 1000 parts of coin there are 900 parts of pure gold and 100 of alloy.

[1] Harris's *Principles and Practice of Dentistry*, Austen, p. 537.
[2] *Dental Cosmos*, vol. vii. p. 395.

When we have the purity of the alloy expressed in thousandths, we can readily ascertain its carat, and *vice versâ*. Thus, for example, if we desire to find the carat of the American gold coin, which is $\frac{900}{1000}$ fine, the statement is made in this manner:

$$1000 : 900 :: 24 : 21.6, \text{ the required carat;}$$

or, having the fineness of an alloy expressed in carats, we desire to reduce it to thousandths.

Take, for instance, the American coin, 21.6 fine; to reduce it to thousandths the statement is thus made:

24 : 21.6 : : 1000 : 900, the number of parts of pure gold in 1000 of the alloy.

Or, again, if we have the weight of an alloy, and its fineness is expressed in thousandths, we can readily find the quantity of pure gold in the mass. For example, to find the amount of pure gold in an American eagle, weight 258 grains, fineness $\frac{900}{1000}$, the statement is made thus:

1000 : 900 : : 258 : 232.2 grains, the amount of pure gold contained in this coin.

Rules for Alloying, etc., the Purity of the Gold expressed by Carats.

1. When the carat is known, to ascertain the quantity of pure gold in the mass.

RULE.—Multiply the weight of the mass by the carat, and divide the product by 24.

Or, let c represent the carat;
" w " " weight.

Formula, $\frac{w \times c}{24}$ = quantity of pure gold.

EXAMPLE 1.—To find the quantity of pure gold in 156 grains of an alloy 19 carats fine.

By the formula we shall have—

$$\frac{156 \times 19}{24} = \frac{2964}{24} = 123\tfrac{1}{2} \text{ grains of pure gold.}$$

EXAMPLE 2.—To find the quantity of pure gold in 258 grains of 21.6-carat gold (an American eagle).

$\frac{258 \times 21.6}{24} = \frac{5572.8}{24} = 232.2$ grains, the amount of pure gold in an American eagle.

2. To ascertain the carat of a formula for an alloy composed of gold of a known carat and an alloy containing no gold.

RULE.—Multiply the weight of gold by its own carat, and divide the product by the weight of the mass.

Or, let a represent the weight of gold;
" c " its carat;
" w " the weight of the mass.

Formula, $\frac{a \times c}{w}$ = carat of the mass.

EXAMPLE 1.—To find the carat of the following formula, composed of pure gold and alloy containing no gold:

Pure gold (24-carat)	80 grains.
" silver	10 "
" copper	20 "
Weighing	110 grains.

By the formula, $\frac{80 \times 24}{110} = \frac{1920}{110} = 17.45$, the carat of the mass.

Example 2.—To find the carat of the following formula, composed of alloyed gold and an alloy containing no gold:

22-carat gold	48 grains.
Silver	16 "
Copper	12 "
Weighing	76 grains.

By the formula, $\frac{48 \times 22}{76} = \frac{1056}{76} = 13.89$, the carat of the mass.

3. To find the carat of a mass composed of different qualities of gold, the carat and weight of each quality being known.

Rule.—Multiply the weight of each quality by its own carat, and divide the amount of the products by the weight of the whole mass.

Example.—To find the carat of a mass of gold composed of 10 ounces of 20-carat gold, 15 ounces of 12-carat, and 20 ounces 10-carat.

$$10 \times 20 = 200$$
$$15 \times 12 = 180$$
$$20 \times 10 = 200$$

Weight, 45 ounces. 580

$\frac{580}{45} = 12.88$, the carat of the mass.

4. To reduce gold to a lower carat by adding an alloy containing no gold.

Rule.—Deduct the required carat from the carat to be lowered, then divide the remainder by the required carat; the quotient, multiplied by the weight of gold to be reduced, will give the quantity of the alloy to be added.

Or, let a represent the carat to be lowered:
" b " " required carat;
" w " " weight of gold.

Formula, $\frac{a - b}{b} \times w =$ weight of alloy.

Example 1.—To reduce 200 grains of pure gold (24-carat) to 18-carat.

By the formula, $\frac{24 - 18}{18} \times 200 = \frac{6}{18} \times 200 = \frac{1200}{18} = 66.6$ grains of alloy to be added.

Example 2.—To reduce 258 grains of 21.6-carat gold (an American eagle) to 18-carat.

By the formula, $\frac{21.6 - 18}{18} \times 258 = \frac{3.6}{18} \times 258 = \frac{928.8}{18} = 51.6$ grains of alloy must be added.

5. To reduce gold to a lower carat by adding to it an alloy of gold of a standard lower than the desired carat.

Rule.—Subtract the required carat from the carat to be lowered; divide the remainder by the difference between the required carat and the carat of the coarser alloy; then multiply the quotient by the weight, and it will give the weight of the coarser alloy to be added.

Or, let a represent the carat to be lowered;
" b " " required carat;
" c " " carat of coarser alloy;
" w " " weight of gold to be reduced.

Formula, $\frac{a-b}{b-c} \times w =$ weight of coarser alloy.

EXAMPLE 1.—To reduce 4 ounces of pure gold (24-carat) to 18-carat by adding 12-carat gold.

By the formula, $\frac{24-18}{18-12} \times 4 = \frac{6}{6} \times 4 = 4$, the number of 12-carat gold that must be added.

EXAMPLE 2.—To reduce 4 ounces of 22-carat gold to 18-carat by adding 12-carat gold.

By the formula, $\frac{22-18}{18-12} \times 4 = \frac{4}{6} \times 4 = \frac{16}{6} =$ 2 oz. 5 dwt. 20 grs. of 12-carat to be added.

6. To raise the carat of an alloy by adding pure gold or a finer alloy.

RULE.—Deduct the carat to be raised from the required carat, and divide the remainder by the difference between the required carat and the carat of pure gold (24), or that of the finer alloy (whichever is used), and then multiply the quotient by the weight, and it will give the weight of pure gold or finer alloy to be added.

Or, let a represent the carat of pure gold or finer alloy;
" b " " required carat;
" c " " carat to be raised;
" w " " weight of alloy to be raised.

Formula, $\frac{b-c}{a-b} \times w =$ weight of pure gold or finer alloy.

EXAMPLE 1.—To raise 240 grains of 15-carat gold to 20-carat by adding pure gold (24-carat).

By the formula, $\frac{20-15}{24-20} \times 240 = \frac{5}{4} \times 240 = \frac{1200}{4} =$ 300 grains of pure gold to be added.

EXAMPLE 2.—To raise 45 ounces of 12.88-carat gold (see Rule 3) to 18-carat by adding gold of 21.6 carat (U. S. coin).

By the formula, $\frac{18-12.88}{21.6-18} \times 45 = \frac{5.12}{3.6} \times 45 = \frac{230.40}{3.6} = 64$, the number of ounces of coin to be added.

The following table will show the fineness of gold, expressed in thousandths, for all carats from 1 to 24 inclusive:

Carats.		Thousandths.	Carats.		Thousandths.
1	=	41.66	13	=	514.66
2	=	82.50	14	=	583.33
3	=	125.	15	=	625.
4	=	166.66	16	=	666.66
5	=	208.33	17	=	708.33
6	=	250.	18	=	750.
7	=	291.66	19	=	791.66
8	=	333.33	20	=	833.33
9	=	375.	21	=	875.
10	=	416.66	22	=	916.66
11	=	458.33	23	=	958.33
12	=	500.	24	=	1000.

Gold and Mercury.—These metals unite with each other in all proportions to form an amalgam which may have a consistency varying from liquid to solid, according to the amount of gold which it contains. A compound of gold and mercury of definite proportions is probably formed when the metals are mixed in about the proportion of 6 parts of mercury to 1 part of gold, as such an amalgam tends to form four-sided prismatic crystals. Union of the two metals is easily effected, as they exhibit considerable affinity for each other, the solution or combination taking place in the cold, but the action is greatly facilitated by the aid of gentle heat. The method of coating brass or copper articles with a film of gold by the process of fire-gilding depended upon the use of gold amalgam, which was prepared after the following method: 1 part of gold was added to 8 parts of mercury contained in a clean iron dish or saucepan, and gently heated with constant stirring till solution of the gold was complete, after which the amalgam was poured out on to a clean glass plate and allowed to cool. The brass or copper articles to be gilded, after being perfectly cleansed, were given a thin, superficial coating of mercury by brushing them over with a solution of mercuric nitrate, after which a thin layer of the gold amalgam was rubbed on, the mercurial coating upon the brass rendering adhesion of the gold amalgam perfect. Heat was then applied to the article by means of a charcoal fire or otherwise until all the mercury slowly volatilized, after which the remaining gold film, which was of a loosely coherent texture and dull brownish-yellow color, was burnished or polished.

An amalgam of gold was proposed at one time for forming a rim upon gold plates intended for use in the mouth, the process consisting simply in building on or forming the rim with gold amalgam and then volatilizing the mercury, after which the remaining gold was condensed with the burnisher. Very accurate adaptation of the rim to the tops of the teeth was thus obtained, but the rims so made failed from lack of homogeneity and strength.

Gold in the form of coherent sponge-like masses or cakes was also at one time prepared for use in filling teeth by volatilizing the mercury from gold amalgam or by removing the mercury by means of nitric acid. The preparation of sponge gold by the latter process is thus described by Dr. George Watt: "Gold precipitated from its solution in aqua regia by protosulphate of iron and carefully washed and dried is combined with pure mercury by friction and trituration with a pestle in a Wedgewood or glass mortar. As the metals combine much of the mercury is oxidized. The oxide is removed by washing with alcohol or warm water. The proper quantity of mercury cannot be ascertained by weighing, as far more of it is oxidized sometimes than at other times. The amalgam should be sufficiently fluid to run perfectly level and smooth on the flat bottom of a glass dish or basin. The glass basin containing the amalgam is to be placed in a steam-bath and nearly filled with diluted nitric acid. The acid should be so diluted that red or orange fumes are barely, if at all, visible from its action on the mercury. When the mercury is all dissolved the gold is to be washed free from acid and annealed to a bright-red heat."

Tin and gold possess a marked affinity for each other (see Matthiessen's experiment, *infra*), and the resulting alloy appears to be a true chemical compound, as considerable contraction of volume with a corresponding increase in specific gravity above the calculated mean takes place when they are united. The effect of tin when alloyed with gold is to destroy its ductility and malleability, conferring upon it great brittleness and rendering it unfit for rolling into plate. The same is true with regard to the metals lead, bismuth, and antimony; hence great care must be exercised in remelting scraps of gold plate to guard against the accidental introduction of particles of these metals, as even minute traces of them destroy the working qualities of the gold. The same effect is also strongly marked in gold-foil used for fillings. Dr. G. S. Fouke in a paper read before the Maryland Association of Dentists, March 28, 1867, makes the statement that "1 grain of tin in 10,000 grains of pure gold is sufficient to entirely destroy its cohesive property."

Lead, bismuth, antimony, and arsenic form brittle alloys with gold in which the color of the latter is very much impaired or lost. Simple fusion, even at elevated temperatures, does not serve to perfectly eliminate them, and recourse must be had to refining processes when gold becomes so contaminated. Minute proportions of arsenic render gold brittle without changing its color. Antimony is more readily separated from gold by heating to a high temperature than arsenic, but the last traces are difficult to expel.

Zinc and gold possess a strong affinity for each other, and the metals unite apparently in all proportions to form alloys. The use of zinc as a substitute for mercury in the extraction of gold from its ores was suggested by M. d'Heureuse, who found that the zinc attacked and dissolved nearly every particle of gold in ores subjected to it while in the melted state, and that the zinc could be readily distilled from the gold and recovered by condensation, to be used over again. All the alloys of zinc and gold are more or less brittle according to the amount of zinc which they contain. Zinc also greatly impairs the color of gold. When the metals are united in equal proportions the alloy is white, hard, and brittle. 11 parts gold and 1 part zinc yield a pale greenish-yellow alloy which is brittle. Very small quantities of zinc may be added to gold without destroying its ductility, but the quality is greatly impaired thereby. Gold scraps frequently become contaminated with zinc in the dental laboratory, which renders the metal unworkable even when repeatedly melted and cast; recourse must therefore be had to one of the various refining processes—*i. e.* by fusion with nitre, corrosive sublimate, or sulphide of antimony—which will ensure its complete removal.

Gold and palladium form a hard alloy: the latter metal has a marked effect in modifying the yellow color of the gold. When the palladium exists to the amount of 15 per cent. the alloy is rendered nearly white and extremely hard. Traces of palladium in gold are stated by Mr. Makins to render it quite brittle, though several alloys of gold and palladium where the latter is in considerable amount are stated to possess ductility and malleability—properties incompatible with brittleness.

Iridium forms a yellow ductile alloy with gold.

Platinum alloyed with gold increases its hardness, but impairs its color when present in considerable quantity; it also raises the fusing-point, so that plates made of coin gold which has been reduced to 20-carat standard can be soldered with 20-carat gold in which the alloy is silver. Successive additions of platinum to gold increase the temperature necessary for its fusion till a point is reached where it becomes impossible to melt it in the ordinary blast-furnace, and recourse to the oxyhydrogen blowpipe becomes necessary. The alloys of gold and platinum are to a certain extent soluble in nitric acid and fused potassium nitrate.

The elasticity conferred upon gold by alloying with platinum exceeds that of the similar alloy of silver and platinum. Care must be exercised in the addition of platinum to gold plate to avoid an excess of platinum, which would impair the toughness of the alloy, and also to have the metals thoroughly and perfectly incorporated with each other by repeated fusions. About 2 grains of platinum to the pennyweight of 18-carat gold plate yields a metal suitable for clasps, etc.

Rhodium forms malleable alloys with gold.

Iron does not seriously interfere with the working qualities of gold when alloyed with it, such a combination being sometimes used by jewellers under the name of blue gold. 1 part of iron with 11 parts of gold is said to form a malleable alloy.

Compounds of Gold.—The non-metallic compounds of gold are in general characterized by the feebleness of their chemical union, all being more or less easily decomposed by heat and by reducing agents. Two compounds of gold with oxygen are known. Auric oxide, Au_2O_3—sometimes spoken of as auric anhydride, from the fact that it forms a number of salts in which it plays the part of an acid—is a brown amorphous powder which is readily decomposed by heating to a temperature of 240° C. It is prepared by adding a solution of potassium hydrate to a solution of auric chloride until the precipitate which is at first formed is completely redissolved. Sulphuric acid is then added to the solution, which throws down the oxide upon boiling, which is again dissolved in strong nitric acid and reprecipitated by largely diluting the nitric-acid solution with water. By treating auric oxide with potassium or sodium hydrates crystalline aurates of these bases are formed. They have been used in the process of electro-gilding.

Aurous oxide, Au_2O, or gold suboxide, is produced as a dark-violet powder by the action of potassium hydrate upon aurous chloride. It decomposes into gold and oxygen at a temperature of 100° C., and by the action of hydrochloric acid is converted into auric chloride, $AuCl_3$, and metallic gold. Aurous oxide does not exhibit the tendency to form double salts shown by the higher gold oxide.

Compounds of gold with sulphur corresponding to the two oxides are known, though they have not been fully investigated. Sulphuretted hydrogen throws down from gold solutions a black precipitate consisting of both sulphides, Au_2S and Au_2S_3. Auric sulphide dissolves in alkaline sulphides with the formation of sulpho-salts. The sodium sulphaurate, $Na_2SAu_2S + 8.H_2O$, has been thus formed.

Sodium sulphaurate may also be formed by acting upon metallic gold by fused sodium sulphide, which dissolves the metal. The discovery of this fact of the solubility of gold in alkaline sulphides is credited to M. Stahl, who over a century ago undertook to investigate the problem of "how it was possible for Moses to burn the golden calf which the Israelites had set up and worshipped while he was on the mount—how he could afterward reduce the calf to powder and throw it into the water which the people used, and make all who had apostatized drink thereof, as related in the book of Exodus." His inquiry resulted in the discovery of the solubility of gold in alkaline sulphides, from which, curiously enough, he came to the conclusion that "there were good reasons to believe that this was the method pursued by Moses to effect the solution of the golden calf."

Two chlorides of gold are known—viz. auric chloride, $AuCl_3$, and aurous chloride, AuCl. Auric chloride is the most important salt of gold, and results from the action of chlorine or nitro-hydrochloric acid (aqua regia) upon the metal. By careful evaporation of its solution the salt is obtained as a reddish-brown, deliquescent, crystalline mass readily soluble in water, alcohol, and ether. From it nearly all the compounds of gold and preparations of the pure metal used in the arts are produced. Its molecular weight is 303.1. It is easily decomposed by many organic substances and even sunlight into metallic gold with evolution of chlorine. Aurous chloride, AuCl, is produced by heating auric chloride to a temperature of about 150° C. Chlorine escapes from the auric chloride, and aurous chloride is obtained as a pale-yellow powder nearly insoluble in cold water. Upon ignition the salt is decomposed into metallic gold and chlorine; boiling water converts it into auric chloride and metallic gold. Its molecular weight is 232.1.

The corresponding iodides and bromides of gold have been formed, also a phosphide and arsenide, the latter substance being found native in some of the Australian gold-fields. There is also probably a silicate of gold, which is believed to be the compound which imparts the color to the finer grades of ruby glass, which is made by adding gold chloride to the silica, which is fused with borax and litharge in forming this variety of glass.

A salt much used in photography, the gold and sodium hyposulphite, or *sel d'or* of the photographers, is prepared in a state of purity by adding 1 part of auric chloride and 3 parts of sodium hyposulphite in concentrated solution: the salt crystallizes in colorless needles which are freely soluble in water, but insoluble in alcohol.

Auric potassium cyanide is formed by the addition of potassium cyanide to auric oxide or sulphide; upon evaporating the solution large colorless prisms of the double cyanide crystallize out. This salt is easily decomposed by the galvanic current, hence it is largely used in electro-gilding.

Fulminating gold, a compound which explodes violently by friction or gentle heating, is formed when ammonium hydrate is added to a solution of auric chloride: the fulminate is thrown down as a yellowish-brown precipitate. Care should be exercised to avoid its accidental formation during the treatment of gold solutions, as its sudden explo-

sive violence might entail serious results. A similar compound is formed when auric acid is digested with ammonia; in this case the auric acid is converted into an olive-green powder which possesses equally violent fulminating properties.

Purple of Cassius.—When a sheet of tin-foil is immersed in a solution of auric chloride a purple-colored compound is formed which is believed to be a mixture of auric, aurous, stannic, and stannous oxides, and which has been named for the discoverer, M. Cassius. It is a vitrifiable pigment used for imparting to glass and porcelain a fine red or ruby tint. It has a special interest in dentistry, as it is the material by which the gum color of dental porcelain is obtained. A variety of methods are given for its production, and much contrariety of opinion exists as to its exact chemical structure: the latter fact is no doubt due to the different ways in which it is produced, which yield compounds which differ considerably in the proportions of their component elements without a corresponding difference in physical properties.

The following table will show the ultimate composition of various specimens of this curious compound made by a number of investigators, the differences obtained being greater than can be accounted for on the ground of errors or differences of method pursued in the analysis, and are no doubt due to variations in the manner of preparation:

	Gold.	Oxide of tin.
Oberkampf, purple precipitate	39.82	60.18
" violet "	20.58	79.42
Berzelius	30.725	69.275
Bouisson	30.19	69.81
Gay-Lussac	30.89	69.11
Fuchs	17.87	82.13

When a solution of stannous chloride is added to a dilute solution of auric chloride a purple flocculent precipitate falls, which is the coloring matter in question. The conditions under which the compound is formed greatly modify its properties.

Fuchs advises the addition of a solution of stannous chloride to a solution of ferric chloride until the latter assumes a green tint. When this stage is reached it is to be added drop by drop to a very dilute solution of auric chloride free from nitric acid. By this process he asserts that the purple powder, which is fully deposited in about twenty-four hours, is always obtained of a finer tint and of uniform composition.

Pelletier's method is as follows: 20 grains of gold are dissolved in 100 grains of aqua regia containing 20 parts nitric to 80 parts commercial hydrochloric acid; the solution is evaporated to dryness over a water-bath; the residue dissolved in water; the filtered solution diluted with 7 or 8 deciliters of water and tin filings introduced into it. In a few minutes the solution becomes brown and turbid and deposits a purple precipitate, which merely requires to be washed and dried at a gentle heat. The purple thus prepared contains, in 100 parts, 32.746 parts of stannic acid, 14.618 of protoxide of tin, 44.772 of aurous oxide, and 7.864 of water. The precipitate obtained by the addition of stannous chloride to auric chloride is always brown. To obtain a fine purple

precipitate the auric chloride should be treated with a mixture of stannous and stannic chlorides.

Bouisson's method, which yields a fine purple, is as follows: *a*, a neutral solution is prepared of 1 part of tin in hydrochloric acid; *b*, a solution of 2 parts of tin in cold aqua regia (1 part of hydrochloric acid to 3 of nitric acid), the liquid being merely heated toward the end of the process that it may not contain any protoxide of tin; *c*, 7 parts of gold are dissolved in aqua regia (6 hydrochloric to 1 nitric), and the solution, which is nearly neutral, diluted with 3500 parts of water. To this solution *c* the solution *b* is first added, and then the solution *a*, drop by drop, till the proper color is produced. If the quantity of *a* be too small, the precipitate is violet; if too large, it is brown. It must be washed quickly, so that the liquid may not act upon it too long. It weighs $6\frac{1}{2}$ parts.[1]

Frick advises the following method: Digest tin in very dilute aqua regia until the liquid becomes faintly opalescent, when the metal must be taken out and weighed to estimate by difference the amount dissolved. The liquor is to be largely diluted with water, and definite weights of a dilute solution of auric chloride and dilute sulphuric acid are to be simultaneously stirred into the nitro-muriate of tin. The solutions must be so arranged that the gold in the one shall be to the tin in the other in the proportion of 36 to 10.

The dry method of producing purple of Cassius is the one now in use by manufacturers of porcelain teeth for the production of gum-enamel, and consists in acting upon a triple alloy of gold, tin, and silver by nitric acid. The discovery of the dry method is credited to the late Prof. Elias Wildman, whose investigations led to the present high state of excellence reached in the manufacture of bodies and enamels for the production of artificial teeth. The proportions of the alloy are—

Pure silver	240	grains.
" gold	24	"
" tin	17.5	"

The gold and silver are first melted together in a borax-lined crucible, sufficient borax being added to completely cover the button of metal. The tin is next added, and the alloy quickly poured in a thin stream from a height into a vessel of cold water. It should be remelted and granulated as above at least four times to ensure intimate combination of the metals. When this is accomplished the pieces of alloy are to be collected and freed from adhering borax, and treated in a glass flask with chemically pure nitric acid diluted in the proportion of 2 parts of acid to 1 part of water. The flask and contents are then to be exposed to gentle heat on a sand-bath. When solution of the silver is complete the flask is allowed to stand until the purple precipitate all subsides; the supernatant solution is then to be poured off and the precipitate repeatedly washed with warm distilled water, after which it is again subjected to the action of dilute nitric acid with the aid of heat and frequent stirring with a glass rod to dissolve any remaining portions of silver. After subsidence of the precipitate pour the contents of the

[1] Graham's *Elements of Inorganic Chemistry.*

flask upon a filter and wash with water; test the washings with sodium chloride to see that they are free from silver nitrate, the presence of which will be indicated by an opalescence or the formation of a curdy white precipitate. When washed free from silver the precipitate of purple of Cassius after drying is ready for use in the manufacture of gum frit, the composition and production of which do not come within the limits of this article.

Piggott[1] gives the following proportions for the alloy from which to form purple of Cassius by the dry method:

Pure gold	20	parts.
" tin	35.1	"
" silver	150	"

Purple of Cassius is completely soluble in liquor ammonia, forming a purple solution from which, on standing for some time, the compound is reprecipitated by escape of ammonia; the action is hastened by gentle heat: potassium and sodium hydrates do not dissolve it. Upon ignition it becomes insoluble in ammonia through the decomposition into metallic gold and stannic oxide. That ignition does effect such decomposition is proven by the fact that the ignited powder can have all of its gold extracted by aqua regia, leaving pure stannic oxide, or the gold may be extracted from it by amalgamation with mercury, which is impossible before ignition. While much doubt has existed regarding its true chemical composition, owing to the causes before stated, it seems to be now settled with a reasonable degree of certainty that it is a compound of aurous oxide with stannous and stannic oxide, which are stated by Bloxam[2] to be grouped according to the formula,

$$Au_2O.SnO_2,SnO.SnO_2 + 4H_2O.$$

The compound is one of considerable stability, as it simply loses water, but no oxygen, upon heating to redness, and regains its former appearance on cooling.

Detection of Gold.—Hydrogen sulphide throws down a black precipitate of auric sulphide in gold solutions which is insoluble in hydrochloric acid, but soluble in ammonium sulphide.

Oxalic acid or ferrous sulphate precipitates the metal as a brown powder which is recognizable by the characteristic orange-yellow color of its metallic lustre, developed by burnishing it.

A mixture of stannous and stannic chloride produces a purple coloration or precipitate of purple of Cassius. Heated on charcoal before the blowpipe, metallic gold is produced.

An exceedingly delicate test for the detection of gold in dilute solutions is that devised by Mr. Skey, analyst to the Geological Survey of New Zealand, which consists in digesting the suspected substance with its own volume of an alcoholic solution of iodine for a few minutes. A piece of Swedish filter-paper is then saturated with the clear supernatant liquid, and afterward burned to an ash, to which a purple color is imparted if the merest trace of gold was present in the substances acted upon. If the substance contains no gold, the paper burns to a white

[1] Piggott's *Dental Chemistry and Metallurgy*, p. 309.
[2] Bloxam's *Chemistry, Inorganic and Organic*, p. 454.

ash. The test is of such delicacy that two grams of ore, which were known to contain not over one ounce of gold to the ton, yielded a distinct purple coloration to the ash of the filter-paper. The coloring matter was quickly removed by bromine, a clear indication of the presence of gold.

Determination.—Gold is always weighed and estimated in the metallic state. All compounds of gold which contain no fixed acid furnish the metal in a suitable condition for weighing upon simple ignition. Where this method is inapplicable, the metal may be precipitated from its solution, which must be free from nitric acid, by means of oxalic acid or ferrous sulphate.

Determination of gold by the process of dry or fire assaying is accomplished by several methods, all more or less similar, the choice of which depends upon the character of the impurities associated with the gold. Two general classes of auriferous substances are met with: first, minerals or ores including incidental industrial products; and second, metallic gold or bullion and alloys, native or artificial.

Assays of gold and silver ores are made in about the same manner, so that a general description will answer for both. After a sample has been carefully taken which will represent as accurately as possible a fair average of the ore to be assayed, the next step is to dissolve the precious metals from the earthy matters and collect them in a button of lead; this is accomplished either by a crucible assay or by scorification.

In the crucible assay a weighed quantity of ore is mixed with a suitable quantity of litharge, reducing agents, and flux, and the mixture heated in a clay crucible to quiet fusion. The metallic lead which is reduced from the litharge seizes upon and dissolves the precious metals, and collects in a button at the bottom of the crucible, while the foreign matters form with the fluxes a fusible slag which floats above. For the crucible assay a convenient charge is of about the following proportions:

Ore	2 grams.
Litharge	25 "
Sodium bicarbonate	10 "

Common salt, sufficient to form a deep cover over the fused mass.

When the impurities or gangue are of a basic nature, silex is used as a flux. Ores containing large amounts of sulphur, arsenic, antimony, or zinc should be roasted in an iron pan before fusion with litharge.

After fusion is complete, which usually requires from thirty to forty minutes, the crucible should be tapped on the floor to cause all the globules of metal to settle to the bottom, when the contents may be poured into a mould or the crucible allowed to cool, when it may be broken open with a hammer and the button obtained.

The scorification assay is conducted in the muffle-furnace as follows: A weighed portion—say, three grams—of finely-pulverized ore is mixed with from fifteen to twenty grams of granulated lead and placed in a scorifier, which is a shallow saucer-shaped vessel made of refractory clay. On top of the charge of mixed ore and granulated lead are placed from fifteen to twenty grams more of pure granulated lead, so as to form a cover; two or three lumps of borax glass the size of a pea are placed on top of this. The scorifier and charge are now placed in the

muffle, and a strong heat applied, at first to melt the lead. As soon as the lead is fully fused, the heat may be somewhat lowered by removing the muffle-stopper. At this stage the ore will be seen floating upon the surface of the lead, and the process of roasting commences. A moderate heat is continued until no more fumes arise and the ore has disappeared. The heat is now raised until all the material is completely fused and clear white fumes of lead oxide arise from the scorifier. There is a play of colors across the surface of the lead, and the slag encircles the metallic bath like a ring. The borax glass is of importance during this stage in giving liquidity to the slag, so that it can be thrown to the side as fast as formed and expose the lead surface for oxidation. If borax glass is not added, and the ore contains much gangue, and is not easily fusible, the scoriæ will float in masses over the lead and impede oxidation.

When fusion is complete the heat is lowered to a point until the ring of slag, which is continually growing smaller, closes over the lead. The heat should again be raised to liquefy the slag and allow the lead to settle, after which the scorifier is removed from the furnace and cooled or poured.

The lead button holding the other base metals, with the gold and silver originally contained in the ore, which is obtained by either the crucible or scorification assay, is next subjected to the process of cupellation, which is described in the section on Silver. (See p. 873.)

The bead or button obtained by cupellation is detached from the cupel with pincers, thoroughly cleansed with a brush, and weighed. It is then ready for the next operation of inquartation, which consists in alloying it with from two to three parts of silver, in order that it may be acted upon by nitric acid in the final operation of parting. The experienced assayer judges by the color of the bead as to the quantity of pure silver which it is necessary to add. When this has been determined, the requisite quantity of pure silver in the form of foil is added to the bead, and they are fused together on charcoal before the blowpipe or by wrapping the bead and silver in a cornet of lead-foil and cupelling them together. The button of pure gold and silver is next flattened by hammering on an anvil or passing it between the rolls of a rolling-mill, and wound into a spiral around a rod or pencil. It is then subjected to the parting operation in a porcelain capsule by means of nitric acid of 1.16 sp. gr. Enough acid is poured upon the spiral to cover it, and a gentle heat is applied. The acid must be free from chlorine, which would cause partial precipitation of the silver. When all action of the first portion of acid has ceased, it is decanted, and some fresh acid of 1.26 sp. gr. is carefully added, and the heating continued for several minutes. The acid is then poured off, and the residue of gold is thoroughly washed with distilled water and dried. The spiral is now detached with a knife, transferred to a cornet of lead-foil, cupelled, and weighed, or if perfectly clean and yellow it may be weighed without cupellation. The quantity of silver is easily determined in the nitric-acid solution obtained from the parting operation, by titration with a standardized salt solution, as directed in the section on Silver (p. 875.)

The results obtained by the foregoing method are open to several

sources of error which lead to inaccuracy. Thus, loss of gold may occur in the muffle by too high a heat, causing volatilization of portions of the metal, or loss may be occasioned by retention of metal in the cupel, or solution in the acid during the parting operation. In either of these the results obtained would fall below the actual truth. Or the figures obtained may be a trifle high, owing to the retention of silver or copper in the spiral. In view of these sources of error it is customary in exact work of this character to conduct a "check assay" upon pure gold along with the ore assay, with which the latter is weighed in comparison. The fineness and weight of the gold used in the check assay thus afford an accurate measure of the amount of error made in the various steps of the operation.

Alloys containing gold are assayed by scorification of the weighed sample in the muffle with test lead, and afterward cupelling and parting in the same manner as described for the assaying of gold ores.

In assaying sweepings, etc. from the laboratories and workshops of dentists and jewellers the material is first ignited to remove organic substances; the residue is then sifted, and where metallic particles are evident they are collected and an assay of these is made separately. The details of the process are the same as those already given. In the assaying of dentists' and jewellers' scraps platinum and iridosmine may be present in the button obtained by cupellation, in which case the amounts of each of the noble metals present may be determined by the following method from Ricketts: "Take 200 milligrams of the alloy and from 150 to 200 milligrams of pure silver; wrap in sheet lead and cupel; weigh the button obtained, and the loss which it has sustained will represent the amount of base metals in the original alloy. Flatten, anneal, and roll the button out thin; anneal again and make into a cornet or spiral, as in the gold-bullion assay. Part the cornet with concentrated sulphuric acid, boiling for several minutes. Wash, anneal, and weigh. The difference between this weight and the button from cupellation gives the weight of the silver in the alloy plus the weight of the silver added. Alloy the weighed cornet with twelve to fifteen times its weight of silver; roll out, anneal, and make into a fresh cornet; then part with nitric acid, sp. gr. 1.16, and afterward with nitric acid, sp. gr. 1.26. Wash, anneal, and weigh. The loss equals the weight of the platinum plus the weight of the silver added. Treat the residue with aqua regia, which will dissolve the gold. Wash, dry, and weigh the iridosmine which remains."

Crucible Methods for the Rough Purification of Gold by Fluxes, etc.—Gold and its alloys used in the production of dental mechanism often become unworkable by accidental additions of other metals, and while in all instances it is best to send such debased metal to a practical refiner, or, better, to the mint, for treatment, and start with either pure gold or an alloy of it in which the exact amount and character of the alloying metals are known, still circumstances may occasionally arise when such a course is impracticable or undesirable, in which case good results may often be obtained by judicious treatment of the molten metal by fluxes.

A flux is generally defined as a substance which is used to promote

the fusion of metals and refractory substances, to which it imparts fluidity. The term "flux" is, however, capable of a broader application, for a number of fluxes are used for the specific purpose of removing certain impurities in the molten metal, and in the treatment of impure gold by fluxes the choice of the latter depends largely upon the character of the debasing element which it is desired to remove. Fluxes accomplish their object in two ways—either by acting as simple solvents for the impurity, or by forming compounds with it which are soluble in the flux or volatile; in the latter case they are driven off in a gaseous state at the temperature of fusion of the metal. In addition to the foregoing, certain substances are used as fluxes which act in a manner exactly the reverse of those alluded to: these are reducing agents, the function of which is to reduce to a metallic state such metallic oxides as are dissolved in the molten metal and which confer friability or brittleness upon the metal when cast.

The base metals, or those which readily combine with oxygen, may be almost completely removed from gold alloys by the use of potassium or sodium nitrate, which parts with a portion of its oxygen to the base metal which is oxidized, and the alkaline nitrate becomes a nitrite. Borax should be used in addition to the nitrate, as it is an active solvent for the metallic oxide when formed, though at the same time it forms a protective coating upon the surface of the metal which prevents further oxidation of the metal by the atmosphere after action of the nitrate has ceased. The method of procedure is as follows: A sand or French clay crucible is heated to redness, and a sufficient quantity of borax is added to give it a thorough internal coating, after which the metal is introduced and brought to the point of fusion. Potassium nitrate is then dropped cautiously, in small portions at a time, upon the surface of the metal at short intervals, until the violence of its action ceases and the whole mass is in a state of tranquil fusion, when the metal may be cast in an ingot-mould. Iron, steel, zinc, and copper are almost completely removed by this method when thoroughly performed.

When lead or tin constitutes a source of contamination in gold, better results are obtained by treating the metal to the action of mercuric or ammonic chloride, which act by virtue of the nascent chlorine liberated by their decomposition at high temperatures. In the use of these chlorides the metal may be fused in a plumbago crucible, as they are without action upon it. After the metal is brought to a state of fusion a mixture of the flux and fine vegetable charcoal in the proportion of about two parts charcoal to one of the flux is added in small quantities at a time until the metal has been sufficiently treated, which may be determined by removing a small portion from time to time and subjecting it to the ordinary physical tests. Where corrosive sublimate is used as a flux, extreme care should be exercised to avoid injury from inhaling the poisonous vapors: the melting-furnace where it is employed should be provided with a hood and have a perfect draught. Corrosive sublimate is rarely used as a flux, excepting when the metal is known to be contaminated with lead or tin in considerable quantities. If the alloy contains silver, a small amount

of the latter is also removed by the corrosive sublimate. In the ordinary operation of remelting clean scraps of gold plate, etc. the most reliable flux, and the one which yields the most satisfactory results, is the mixture of ammonic chloride and fine charcoal: its action is similar to that of the mercuric chloride, but less violent. It should be projected upon the surface of the metal just at the moment of fusion, when the sal ammoniac exerts its action upon whatever impurities are present, effecting their volatilization as chlorides, while the charcoal remains floating on the molten metal, to which it affords a protective coating from the atmosphere. This flux has the great additional advantage of not in the least interfering with the casting of the ingot in the mould, which in the case of all liquid fluxes constitutes an objection, as the metal has to be skimmed with a stick of wood previous to pouring; otherwise, the flux runs into the mould with the metal, often creating porosity or flaws unless especial care is taken to prevent it.

Gold alloyed with large quantities of silver may be separated from the latter in the crucible by treating the alloy with sulphur or antimonic sulphide, by which the silver is converted into a fusible sulphide, and the gold, upon which the sulphur has no action, may be recovered as a button at the bottom of the crucible. The parting operation with sulphur is conducted by granulating the metal by pouring it from a considerable height in a fused state into water: the granulated alloy is then dried, mixed with about one-seventh of its weight of sulphur, and placed in a crucible with a covering of fine charcoal, where it is heated for some time at a point below fusion, whereby silver sulphide is formed by cementation. The heat is then increased until fusion is complete: the contents of the crucible are then cast into a conical iron ingot-mould which has been previously warmed and oiled. Should the resulting button of metal still contain silver, the operation should be repeated. The silver may be reduced from its sulphide by one of the methods described in the section on Silver.

Sulphide of antimony has been used in the same manner for the removal of silver from gold. The method of conducting the operation is similar to that just described for the use of sulphur, except that the resulting metallic button is to be remelted in a wind-furnace or muffle with access of a free current of air, the heat should be increased to volatilize the antimony, and the resulting button fused with borax and nitre to effect the removal of the last traces of that metal, or the antimony and gold alloy may be directly cupelled with lead.

Potassium carbonate is used as a flux in the recovery of gold from jewellers' and dentists' sweepings. These are first burned to remove organic impurities, and then ground and fused with potassium carbonate, which dissolves the earthy impurities, with which it forms an exceedingly liquid flux, thus enabling the heavier particles of metal to sink through the fluid mass and collect in a button at the bottom of the crucible. This is then cast into an ingot, and further refined by cupellation or by some of the rougher methods of crucible refining, as the case may be.

Sound, tough ingots of metal suitable for rolling can only be obtained by having regard not only to care in refining and treatment of the metal

while in the crucible, but also by a proper attention to the details of casting it into an ingot.

In the production of new alloys the component metals, after being accurately weighed, should be placed in a plumbago crucible, and when near the point of fusion should be covered with a layer of fine charcoal, or some borax may be used, though preference is given to the former, as it not only prevents oxidation, but acts as a reducing agent, which borax does not, so that the relative proportions of the component metals are more nearly maintained when charcoal is used; besides which, it does not interfere in the least with casting, as before noted. When fusion is complete a small amount of sal ammoniac, mixed with fine charcoal, may be thrown upon the surface to ensure a tough alloy: after this has burned off or volatilized, the metal should be stirred with a clean iron rod previously heated to prevent chilling, after which the metal may be cast in the ingot-mould. Particles of charcoal or flux are to be prevented from running into the mould with the metal by holding a thin strip of wood—preferably poplar, as it burns slowly—across the crucible just back of the lip: the metal is thus skimmed as it is poured.

The ingot-mould, which is usually of iron, must be previously warmed and oiled. A proper temperature for the ingot-mould is of the utmost importance. If cold, the metal flies or spurts during casting, which not only occasions loss, but may produce an unsound ingot. If heated too high, the same thing results. The proper temperature can be best learned by experience; but, roughly stated, it is somewhat hotter than can be borne by the hand, probably about 140° F. A thorough oiling of the mould prevents adhesion of the alloy to the sides of the mould and yields a clean surface to the ingot.

As a general rule, alloys should be cast at a temperature not much above their fusing-points, the proper point being one at which they are just fluid enough to run easily and properly fill out the mould. When cast at a minimum temperature, solidification takes place at once and liquation is prevented, and the necessary homogeneity obtained. When cast at too low a temperature, flaws and imperfections in the ingot result, which can only be remedied by remelting and casting at a more elevated temperature.

It has been recommended to anneal and forge the ingot previous to passing it through the rolling-mill, with a view to condensing the metal and making it tougher. Such treatment is, however, of questionable utility, as the condensation produced is at best irregular, and is altogether unnecessary when the alloy is formed in proper proportions and the treatment in the crucible, together with the requisite care in casting, has been carried out in essential details.

Separation of Precious Metals in Dental Scrap by the Wet Process.—The following method may be conveniently employed for effecting the separation of gold, platinum, and silver from each other when they exist together in the scrap-drawer of the dental laboratory.

Fuse the scrap filings, etc. in a plumbago crucible with a sufficient quantity of borax at as high a temperature as possible, continuing the heat until a homogeneous alloy is obtained, which will render its subsequent solution in aqua regia less difficult, as the action will proceed with

greater regularity. Granulate the metal by pouring it in a thin stream into cold water from a height of several feet. Place the granulated alloy in a thin, flat-bottomed flask of sufficient capacity and subject it to the action of aqua regia in the following manner: Two parts by measure of hydrochloric acid of specific gravity about 1.16, and one part by measure of nitric acid of about 1.45 specific gravity, are mixed together. The quantity of mixed acids required is about three and a half ounces for each ounce of gold. The aqua regia thus made should be added in small quantities at a time until all the alloy is completely dissolved, and if necessary a gentle heat on the sand-bath may be employed to effect the solution of the last portions of metal. The use of heat during the greater part of the process is unnecessary as well as inadvisable, as the temperature becomes sufficiently elevated by the energy of the chemical action on the flask, and should the acids be subjected to additional heat the action becomes so violent that much of the chlorine liberated is driven off before it can have time to act upon the metal, which necessitates the use of a larger amount of aqua regia. There is danger also of portions of the solution being ejected from the flask when the action is too violent. When much silver is present in the alloy, the solvent action of the acid is frequently retarded by the formation of a coherent film or coating of argentic chloride, which adheres to the surface of the particles of alloy and prevents free contact of the acid. This is so marked in some instances that the form of the original metallic particles is exactly maintained by this film of argentic chloride, even after complete solution of the metal has taken place. Occasional stirring with a glass rod facilitates the removal of the argentic chloride as it forms, and materially hastens the compact solution of the alloy. When the metal is completely dissolved, the silver will be found as a yellowish-white powder or precipitate at the bottom of the flask, while the supernatant liquid will be of a deep amber-brown color, varying in depth according to the degree of concentration of the solution and the amount of platinum. The contents of the flask should now be transferred to a porcelain evaporating-dish, and evaporated almost to dryness upon a water-bath to expel all remaining traces of nitric acid. When evaporation has been fully performed, a few drops of hydrochloric acid are to be added and the contents of the dish largely diluted with pure cold water. After allowing a sufficient time for the argentic chloride to settle to the bottom of the vessel, the supernatant solution, which contains the gold and platinum, may be decanted from the precipitate; but a safer plan is to separate the argentic chloride by filtration. The precipitate is to be washed free from the gold-and-platinum solution with cold distilled water, and afterward by boiling water, to remove any lead chloride which may have been present. The washings with the cold distilled water may be added to the solution of gold-and-platinum chlorides, while the washings with hot water are thrown away. Metallic silver may then be recovered from the chloride by one of the methods described in the section on Silver.

The solution containing the mixed chlorides of gold and platinum is next concentrated by evaporating it to about one-half or one-third its bulk, and a concentrated solution of ferrous sulphate added cautiously as long as any gold falls, which will be determined when a drop of the

ferrous sulphate solution no longer produces any turbidity. The precipitated gold is allowed to completely subside, and is separated by filtration or decantation, washing thoroughly with water as before, and afterward digested with hot hydrochloric acid several times to remove any traces of iron. The precipitated gold thus obtained may then be fused with borax and nitre and cast in an ingot. The platinum, along with the base metals remaining in the solution from which the gold has just been precipitated, is now to be recovered by evaporating the solution until the point of saturation is reached—that is, until it just shows a tendency to crystallize. An equal bulk of strong alcohol is now added, following which a saturated solution of ammonic chloride is added as long as a bright-yellow precipitate of platinum-ammonium chloride is thrown down. The yellow precipitate thus obtained is collected upon a filter, washed with hot alcohol, dried, and cautiously ignited to expel the chlorine and ammonic chloride. The result is metallic platinum in a spongy state, which requires the heat of the oxyhydrogen blowpipe to fuse it into a compact metallic mass. The base metals remain in the original solution, with the exception of the lead, which was thrown down as chloride with the silver, and removed from it by washing with boiling water, in which it is soluble.

The foregoing method is to be employed where the gold and platinum present are in excess of the amount of silver. The results obtained are sufficiently accurate, when the details are carefully observed, to yield the metals in a state very nearly approaching purity. When iridium is present alloyed with the platinum it goes into solution with that metal, and is reduced with it from the condition of ammonic chloride, conferring upon the platinum increased hardness. For the separation of platinum from iridium the reader is referred to the special technical works upon the subject. When the silver is in excess to the amount of 75 per cent. or more, it may be completely separated by the parting process with boiling sulphuric acid (see p. 833), and the resulting gold and platinum separated after being dissolved in aqua regia by precipitation with ferrous sulphate and ammonic chloride respectively, as just noted.

SILVER.

Symbol, Ag (Argentum). Atomic weight, 108.

Known from the earliest times, silver has been used for coinage, articles of adornment, ornamentation, and plate, for which it is peculiarly adapted by reason of its extreme whiteness, brilliant lustre, and resistance to oxidation. In the peculiar system of the alchemists its correlative planet was the moon, and their nomenclature is occasionally used in modern times. Thus, the term *lunar caustic* is frequently applied to the fused silver nitrate, and the arborescent form of metallic silver obtained by precipitation is spoken of as the *arbor Dianæ*.

Silver was one of the noble metals of the alchemists, so called by them because of its resistance to oxidation at all temperatures, and because from its oxides the metal could be obtained pure by the simple application of heat.

Silver is found pretty widely distributed over the earth's surface. The United States, Mexico, Peru, and Chili furnish the largest amounts. Austria, Hungary, Norway, and Australia also contribute to the supply. Owing perhaps to its lack of chemical activity and want of affinity for other substances, silver is frequently found native in the metallic state. Native silver occurs generally in masses having an arborescent form, which are composed of numerous isometric crystals strung together or in twisted filaments, and sometimes in plates or irregular masses. The metal is usually impure, being associated more or less with gold, copper, arsenic, iron, and other metals. Beautiful specimens of native silver are obtained from time to time in the Lake Superior copper-mines, where it occurs in pockets or intimately associated with native copper, upon the surface of which it shows in specks or blotches readily distinguishable by its pure white color. Large masses of the two native metals thus mixed have been found, some of them weighing many hundred pounds. With mercury it is found in combination to the amount of from 25 to 35 per cent., crystallized in isometric crystals or massive as a native amalgam.

Silver sulphide, AgS, silver glance or argentite, the most important of the ores of silver, several varieties of which exist, is of a blackish or lead-gray color and crystallizes in the isometric system, usually in cubes or octahedra. It is readily distinguishable from galena, with which it is often associated, by its softness, vitreous character, and malleability, which latter property it possesses to a considerable degree, so that medals may even be struck from it when pure. It may be easily cut with a knife, and is quite fusible. Pure silver glance contains 87.1 per cent. of pure silver. Silver sulphide is frequently found associated with sulphides of copper, antimony, arsenic, and iron, giving rise to a number of somewhat complex mineral compounds. Pyrargyrite, or ruby silver, which occurs in magnificent ruby-colored crystals, is a compound of silver sulphide and antimony sulphide, having the formula $3Ag_2S + Sb_2S_3$. Proustite is a corresponding mineral somewhat lighter in color, in which the antimony sulphide is replaced by arsenic sulphide.

Copper and silver sulphides occur associated in the mineral stromeyerite, having the formula $Cu_2S + Ag_2S$. A similar compound of iron and silver sulphides exists as sternbergite, of which the formula is $AgFe_2S_2$.

Cerargyrite, or horn silver, so called from its resemblance to horn in texture and appearance, is a native compound of silver and chlorine, and contains 75.33 per cent. of silver. Its formula is AgCl. It has a pearl-gray or greenish color, is semi-transparent with a resinous lustre, and is soft enough to be marked or indented by the thumb-nail. On exposure to the air a freshly-cut surface turns brown. On rubbing it with a moist plate of zinc or iron, the latter becomes coated with a film of metallic silver. The corresponding native iodide and bromide of silver are known as iodyrite and bromyrite, respectively.

The methods pursued for the recovery of silver from its ores depend of course upon the character of the ore to be operated upon.

Silver is obtained from argentiferous pyrites and ores poor in silver by the amalgamation process. The method varies somewhat in its

details in different localities, but the principles involved are nearly the same. A description of the Saxon method will give a general idea of the process:

The ores are carefully selected and assorted, so that the mixed ore shall contain not more than 7 per cent. of lead and 1 per cent. of copper, as the presence of these metals to any considerable extent causes an undue consumption of the mercury. It is necessary also that the ore should contain a sufficient quantity of iron pyrites for the formation of sulphates, with which to react upon the sodium chloride afterward introduced. The selected ore is incorporated with about 10 per cent. of common salt and roasted at a dull-red heat, whereby the sulphides are converted into sulphates and antimony and arsenic expelled as oxides. The temperature is then raised till the sulphates of the metals formed by the roasting process react with the sodium chloride, forming metallic chlorides (principally ferric chloride) and sodium sulphate.

The iron chloride parts with its chlorine to the silver, converting it into silver chloride, while oxide of iron remains. Other chemical changes take place during this stage of the process, but those indicated are principally concerned in the extraction. When all of the silver is thus converted into chloride, the ore is ground to a fine meal and agitated in revolving oaken casks with water and fragments of wrought iron, the effect of which is to reduce to the metallic state all of the silver and copper, which part with their chlorine to the iron, and such other metals whose chlorides are decomposable by metallic iron. The reduced metals are dispersed through the mud-like mixture of ore and water in a very finely-divided condition. Metallic mercury is now introduced, and the rotation of the casks continued for a number of hours longer, until all of the precipitated silver is dissolved, the reduced copper being taken up at the same time. A considerable quantity of water is next added to thin the mixture and allow the amalgam to settle to the bottom of the cask, after which it is drawn off and strained through heavy canvas bags; by which means the more fluid part of the amalgam, which contains about 20 ounces of silver to the ton, is strained off, leaving a pasty amalgam in the bags which contains about 30 parts mercury, 4 parts silver, and 1 part copper, with small quantities of other metals originally contained in the ore, principally lead, bismuth, zinc, antimony, and gold. The mercury is next separated from the pasty amalgam by distillation, the vaporized metal being condensed under water, and is again used in the amalgamators. After removal of the mercury the residue consists of a spongy mass of silver, copper, etc., which is melted in plumbago crucibles: the ingots obtained are purified from base metals by the cupellation process.

The amalgamation process employed by the Mexican miners is much the same in the principles involved, but the methods are of a cruder and more primitive character and far less economical. Several plans have been suggested whereby the use of mercury might be avoided in the extraction of silver. That known as Augustin's process has been successfully used at Freiberg, and with particularly good results on ores rich in copper which were unsuited for treatment by amalgam-

ation. The ore is roasted with salt in the same manner as for the amalgamation method, care being taken to convert all the silver into chloride. The silver chloride is dissolved out by a hot concentrated solution of common salt, in which it is freely soluble, and the silver recovered by reduction with finely-divided metallic copper, which is converted into chloride by the chlorine of the silver chloride. The reduced silver is dried and fused as before. Hyposulphite of sodium has also been used to dissolve out the silver chloride.

Another interesting process which has been successfully employed for the extraction of silver from argentiferous sulphides is that devised by Ziervogel, in which the mixed sulphides are roasted without the admixture of salt until they are converted by oxidation into sulphates; the heat is then raised sufficiently to decompose the copper and iron sulphates, leaving them as insoluble oxides: the silver sulphate, being more stable, is unaffected, and is afterward dissolved out by boiling water, and reduced by metallic copper to the state of spongy metallic silver, while copper sulphate, or blue vitriol, is formed as a by-product.

Argentiferous galena is smelted for silver in an entirely different manner, and by a process of much interest. Galena almost invariably contains silver, which replaces the lead in combination with the sulphur without causing any alteration of its crystalline form or general appearance, and a galena containing as small an amount as 2 per cent. of silver is profitably worked for the latter metal.

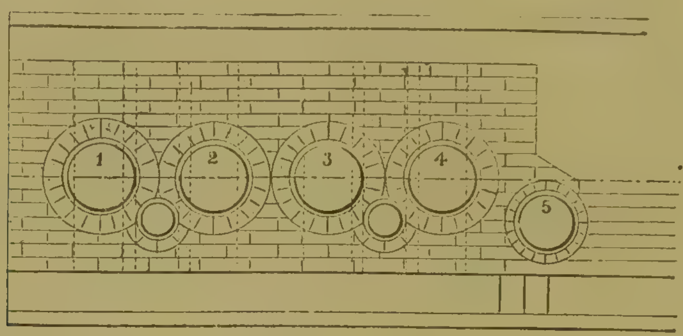
During the process of smelting galena for lead the silver which it contains is reduced at the same time, and remains alloyed with it (see section on Lead for the reactions involved), and the separation of the two metals is effected by first concentrating the alloy by Pattinson's process until it contains about three hundred ounces of silver to the ton, and then cupelling it, whereby the lead and other oxidizable metals are removed as oxides, leaving pure silver.

Pattinson's process, which was introduced about 1829, is based upon his observations—1, that an alloy of lead and silver, within certain limits, has a lower fusing-point than pure lead; and 2, the tendency of the latter to crystallize at a temperature at which the silver-lead alloy will still retain its fluidity. The practical application of these principles is, as described by Bloxam, as follows:

"A series of melting-pots is employed, the number as well as form of which will differ somewhat in different establishments; but for the sake of illustration a desilverizing plant containing five pots may be taken. These pots are made of cast iron and set side by side in masonry. The *working-pots*, 1, 2, 3, 4, are oval in shape, their mouths being 40 by 26 inches, and they are shaped at the bottom like the small end of an egg. 5 is the *market-pot* for melting the desilverized lead before casting into pigs; it is smaller than the others. The smallest pots between 1 and 2 and between 3 and 4 are the *temper-pots*, for containing the melted lead in which the perforated ladle is warmed which is used for fishing out the crystals of lead. This is an iron ladle about 18 inches wide and 5 inches deep, with an iron handle of 4½ feet and a wooden handle of about 5 feet in length; the holes in the ladle are ½ inch wide and ¾ inch apart. Each pot is heated by a separate fire.

"The lead to be refined is usually in pigs weighing from 120 to 140 pounds each. About four tons of these are melted in pot 1. (See Fig. 299.) When they are perfectly melted the fire is raked out and the oxide

Fig. 299.



Pots for Desilverizing Lead.

is skimmed from the surface of the lead. In order to hasten the cooling of the metal, one or two pigs of cold lead are thrown in or a little water is thrown upon the surface, so as to form a solid crust, which is then pushed down into the liquid metal. This is continued until crystals of lead begin to form. The workman then detaches any lead which has solidified on the sides of the pot, and stirs the melted metal with an iron bar in order to preserve an equal temperature throughout. Another workman takes the perforated ladle out of the temper-pot in which it has been heated and fishes up the crystals which have been formed, and tilts the ladle up out of the melted lead by resting the handle upon the edge of the pot, which acts as a fulcrum. The ladle is shaken violently to drain all of the fluid portion back into the pot, and is then swung by a crane over pot 2, into which the crystals are thrown; after this has been repeated for an hour only about one ton of lead richer in silver is left in pot 1, the quantity being ascertained by trying the depth of the metal in the pot.

"The removal of the crystals is still proceeded with, but since these will now contain too much silver to be introduced into pot 2, they are thrown upon the ground in order to be melted up with more lead in pot 1. When only about one half ton of the rich liquid alloy is left in pot 1, it contains about three times as much silver as the original lead, and is ladled out and cast into eight pigs, which often contain as much as 150 ounces of silver in the ton, together with any copper and antimony which were contained in the original lead, whilst any arsenic which was present will have passed into the crystals. The half ton of crystals which have been thrown upon the ground are now melted in pot 1 with a fresh quantity of the original lead, and treated as before.

"The three tons of crystals of lead poor in silver which were transferred to pot 2 are made up to four tons by adding lead of the same richness in silver, and submitted to a repetition of the same treatment, about three-fourths of it being transferred in crystals to pot 3, one-eighth of it in the form of richer crystals being thrown upon the ground to be remelted in pot 2, and the remainder, which is left in the liquid state at the bottom, is ladled out into pot 1. The crystals in pot 3 are treated in the same way, the portion remaining liquid being transferred to pot 2, and the poorer crystals being melted in pot 4. Finally, the crystals of poor lead formed in pot 4 are ladled into pot 5, to be cast into pigs which are treated again, if necessary, until the silver is at last reduced to half an ounce to the ton.

By a single operation in the four pots just described the silver in marketable lead is reduced to one-tenth its original amount."

The rich alloy of silver and lead obtained by Pattinson's process, and which contains anywhere from 300 to 600 ounces of silver to the ton, is subjected to the cupellation process.

An ingenious process introduced by Mr. Parkes is successfully and economically applied to the extraction of silver from certain kinds of argentiferous lead. It is based upon the fact that zinc and lead have no tendency to alloy, no matter how intimately they may be mixed, and that silver and zinc possess a greater affinity for each other than do lead and silver. Consequently, when zinc is melted and well stirred with lead holding silver in solution, on allowing the mixture to slowly cool the zinc rises to the surface, carrying the silver with it. About fifteen tons of silver lead are melted at one operation; the quantity of zinc required depends upon the amount of silver present: for lead holding about 50 ounces of silver to the ton the amount of zinc used is about $1\frac{1}{2}$ per cent. of the charge. The zinc is added in successive portions, and well stirred at a temperature much higher than that employed in the Pattinson process, and the metal is allowed to cool after each addition of zinc until a crust of argentiferous zinc forms upon the surface of the lead, which is lifted out and allowed to drain as much as possible, and placed in a smaller pot for further treatment. The lead is finally obtained free from silver, and containing only from $\frac{1}{2}$ to $\frac{3}{4}$ of 1 per cent. of zinc, which is afterward removed by oxidation in a reverberatory furnace by a poling process with green wood. The zinc is removed from the silver by distillation in plumbago retorts with lime and carbonaceous matter. The resulting silver, which still contains some lead, is refined by cupellation, which, briefly described, is as follows:

The operation known as cupellation[1] is an extremely ancient one, and is based upon the property of certain oxides to filter through or be absorbed by the porous texture of the cupel, while the molten metals remain upon its surface unabsorbed. The process is modified according to the quantities of metal to be treated. On the large scale, specially-constructed furnaces of a reverberatory type are used, capable of cupelling from four to five tons of argentiferous lead in from sixteen to eighteen hours. In such a furnace the cupel is capable of holding 500 or 600 pounds of lead at one time. On a small scale, the operation is conducted in the muffle of an assay furnace or upon a diminutive cupel in the oxidizing flame of the blowpipe. As the principles in each of these operations are precisely the same, the differences being confined to matters of detail, a description of the muffle assay will serve to fully illustrate the method.

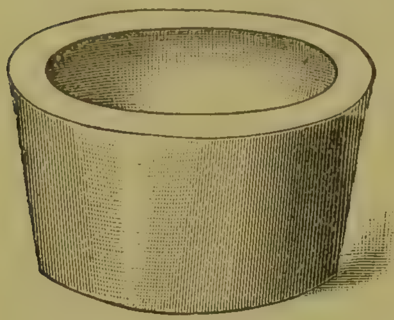
The cupel is made from the ashes of calcined bones, entirely freed from organic matter, ground, and washed. They may be obtained ready made at the supply-shops, but as they are friable and easily broken, it is better to make them as needed, especially if they have to be

[1] The name is believed to be derived from a diminutive of the Latin *cupa*, a cup, referring to the concave hearth upon which the process is carried out.—Bloxam.

carried some distance. The prepared bone-ash can be obtained in bulk, and is mixed with just sufficient warm water to hold it together without being moist. Sometimes a little wood-ashes or potassium carbonate is mixed with the water for moistening the bone-ash.

The cupel is formed by filling and driving the prepared bone-ash into a steel mould made for the purpose. Care must be exercised that the right degree of compression is used, as otherwise the cupel will be either too hard or too porous. If too hard and dense, the cupel will crack on drying; and if too porous, silver will be absorbed along with the litharge and occasion loss. When completed the cupel is of the form shown in Fig. 300. A good cupel should absorb nearly its own weight of litharge. The assay furnace is of the same general character as the muffle furnace employed for the production of continuous-gum work, with the exception that provision is made for maintaining a current or circulation of air through openings at the sides or back of the muffle.

FIG. 300.



Cupel.

To conduct the silver assay a cupel is carefully wiped out to free it from all extraneous matter and placed in the heated muffle, where it is allowed to remain until it has become of the same temperature as the latter, which should be a full red or reddish white. The weighed button or mass of argentiferous lead is then gently placed in the cupel by the aid of a slender pair of tongs, and the muffle closed by a stopper or a piece of lighted charcoal, to bring the metals to the same temperature as the furnace and fuse them as quickly as possible. When this point has been attained, air is admitted: as soon as this is done the surface of the assay becomes coated with a film of oxide, moving in brilliant patches or wavelets over its surface which are continually thrown toward the sides of the cupel, and are there absorbed by the bone-ash. The process during this stage requires much care in its skilful management, as, should the temperature reach too high a point, loss of silver occurs through volatilization. If too low a temperature is reached, fumes of litharge cease to be given off, and what is technically known as *freezing* of the assay takes place, and it cannot be brought to the proper condition of fusion and oxidation without loss of silver, yielding results which are unreliable. The experienced operator is guided in maintaining a proper temperature by observing the color of the muffle, which should be reddish white, the cupel full red, the fused metal luminous and clear, the fumes of litharge rising with a whirling motion over the assay, and not rising straight up or creeping slowly over it—a bright narrow border of litharge upon the fused lead and rapid and complete absorption of the litharge by the cupel.

As the process continues the metallic button gradually diminishes in size; the shining patches of oxide become larger and move with greater rapidity, which indicates the near completion of the process. At the moment the last of the lead is absorbed the button appears to revolve rapidly on its axis; its surface is suffused with iridescent tints for a

moment, and then the brilliant white surface of molten silver appears. This last stage is termed the *brightening* or *coruscation* of the button. It is well at this point to raise the heat of the muffle to ensure the expulsion of the last traces of lead. The assay must be slowly cooled to prevent *spitting* or *vegetation*, which may cause a portion of the metal to be thrown off and lost.

Two causes have been assigned for this phenomenon observed in silver when passing from the liquid to the solid state. First, by rapid cooling a crust is formed which contracts upon the interior, which is still liquid; and second—which is probably the correct explanation—it is due to a property first demonstrated by MM. Lucas and Gay-Lussac, that silver when fused in the air absorbs oxygen, which it gives out again in the act of solidification. They found that the quantity of oxygen thus absorbed may amount to twenty-two times the volume of silver.

The bead obtained by cupellation as just described is carefully cleansed with a brush and weighed. If it contains gold, it is necessary to determine the amount of that metal: it is therefore subjected to the parting operation, the applications of which are described in the section on Gold. The steps for the exact assay of silver bullion are, avoiding minor details, as follows:[1]

A preliminary assay is made by cupellation, by which the approximate fineness of the alloy is determined. For this purpose say 500 milligrams of the alloy are wrapped in lead-foil and cupelled. Suppose a button is obtained weighing 0.43475 grains; then by the proportion,

Original wt. of alloy.		Standard silver.		Wt. of silver found.		Approximate fineness of cupelled alloy.
500	:	1000	: :	0.43475	:	$x = 869.5$,

proper corrections having been made for loss of silver during cupellation. The assay proper is then made by taking such a weight of alloy as will contain 1 gram of pure silver, which in this instance will be 1.145 grams. This is placed in a glass-stoppered bottle of about 8 ounces capacity, and dissolved in 10 cubic centimeters of nitric acid by the aid of gentle heat on a sand-bath, and allowed to cool. A carefully standardized solution of common salt, termed the normal solution, is prepared, of which each 100 cubic centimeters contain just 0.54167 of a gram of salt, which is the amount necessary to precipitate 1 gram of silver. 100 c. c. of this normal salt solution is now added to the solution of the alloy in nitric acid; the whole is agitated and allowed to settle clear. A solution of salt one-tenth the strength of the normal solution, each cubic centimeter of which will precipitate exactly one milligram of silver, is now run into the solution of the alloy, one cubic centimeter at a time, and after each addition it is agitated and allowed to settle clear; this is continued until the last cubic centimeter of decime salt solution fails to cause any precipitate. Suppose 6 c. c. of the decime salt solution have been added, and the last failed to produce a precipitate, giving more than 4 and less than 5 c. c., or 4.5 c. c. There has been used, then, 100.45 c. c. of salt solution, which = 1.0045 grams of silver. The fineness is given by the following proportion:

$$1.145 \text{ is to } 1.0045 \text{ as } 1000 \text{ is to } x = \text{the fineness.}$$

[1] Condensed from Rickett's *Notes on Assaying.*

The *liquation* or *sweating* process for separating silver from copper has already been described in the section on Alloys. (See p. 797.)

Preparation of Pure Silver.—Chemically pure silver may be prepared in several ways. The method employed at the United States mints for obtaining standard silver 1000 fine is as follows:

Tough bar silver is dissolved in strong nitric acid, the solution largely diluted with water, allowed to stand some time, and filtered, and the silver precipitated with pure hydrochloric acid. The white chloride of silver is well washed several times with distilled water, and fused with bicarbonate of soda in a porcelain crucible till the reduction is complete, after which the button thus obtained is again fused with borax to toughen and purify it.

Mohr[1] recommends a mixture of 100 parts pure chloride of silver with 70 parts of chalk and 4 parts of wood charcoal, to be fused together as a means for reducing the argentic chloride and obtaining pure silver, the argentic chloride parting with its chlorine to the calcium of the chalk to form calcium chloride and liberating carbonic acid gas.

In both methods care is required in fusing the mixture, as the evolution of carbonic acid is sometimes so rapid as to cause loss from spirting of the mass when the evolution of gas is violent.

Reduction of the silver chloride may also be accomplished by means of a strip of clean iron or zinc: of these, the latter yields the best results, though neither gives as pure a product as that obtained by fusion with sodium carbonate. The pure washed argentic chloride is acidulated with dilute hydrochloric acid, and a piece of pure zinc introduced, by which a copious evolution of hydrogen is produced: this in its nascent condition effects the reduction of the argentic chloride by combining with its hydrogen, leaving the silver as a gray spongy mass. The vessel should be left undisturbed until the last portion of argentic chloride is decomposed, when the undissolved portion of zinc may be taken out and the silver sponge washed with hot water to remove the zinc chloride formed, and then treated with hot dilute hydrochloric acid to remove any particles of undissolved zinc, and, lastly, with repeated washings of hot distilled water, after which it should be melted with borax and cast. The reactions involved are as follows:

$$Zn + 2HCl = ZnCl_2 + H_2; \quad H_2 + 2AgCl = 2Ag + 2HCl.$$

By an analogous method silver may be precipitated from the solution of its nitrate by means of copper, but the silver obtained by this process is found to be slightly contaminated with copper.

The reduction of argentic chloride as a metallurgical process has been already alluded to in Ziervogel's method for the extraction of silver.

Properties of Silver.—Pure silver is possessed of a brilliant white lustre which is characteristic of the metal. Its specific gravity is 10.5. It is somewhat harder than gold, but softer than copper. In ductility and malleability it is but slightly inferior to gold; hence it has been hammered into leaves only one four-thousandth of a millimeter thick, and drawn into wire so fine that two kilometers of it would weigh but

[1] *Fresenius's Zeitschrift,* xiii. 179.

one gram. Films of silver of extreme tenuity when viewed by transmitted light exhibit a greenish-blue tint. It is superior to gold in tenacity, though inferior to platinum and copper in respect to this property. A silver wire unannealed having a sectional area of one millimeter sustained a weight of 63.80 pounds at the moment of rupture. A similar wire of gold broke at 61.60 pounds; platinum broke at 77.00; copper at 90.20.[1]

Silver is the best conductor of heat and electricity known. It fuses at about 1037° C. or 1900° F.,[2] at which temperature it is slightly volatile: it may be completely volatilized in the flame of the oxy-hydrogen blowpipe, by which it is converted into a greenish vapor. As already stated, it absorbs, while in a state of fusion, about twenty-two times its volume of oxygen, the gas being simply mechanically absorbed, and escaping upon solidification of the metal. It is unaltered in the air at any temperature, but is readily acted upon by chlorine, phosphorus, or sulphur. The latter produces a black stain or tarnish of silver sulphide, which may be easily removed by a solution of potassium cyanide. It is attacked by ozone, which coats it with a superficial film of silver peroxide. The fused alkaline hydrates or nitre are without action upon it, hence it is used to manufacture crucibles and dishes for the fusion of these substances in the chemical laboratory. It is readily soluble in dilute nitric acid, either hot or cold. Hot hydrochloric acid attacks it slightly, the argentic chloride produced forming a protective coating to the metal which prevents its further action. Boiling concentrated sulphuric acid converts it into silver sulphate.

Ascertaining the Purity of Silver.—Professor Stas gives a very simple plan for ascertaining the purity of silver. The pure metal remains melted in the air at a sufficiently high temperature to volatilize it, without being covered by any scum or coloration and without giving a colored vapor. Silver containing no more than the $\frac{1}{500000}$th part of iron, copper, or silicium becomes covered with a very strong and mobile scum when it is fused before a blowpipe fed with a mixture of illuminating gas or hydrogen and an excess of air. Silver containing scarcely appreciable traces of copper when volatilizing in an oxidizing flame always gives a colored flame. This assay may be performed on charcoal or white-burned pipeclay or on porcelain by means of a gas blowpipe or a simple eolipyle. The scoria derived from the impurities in the metal always forms upon the surface of a flattened spheroid caused by the fusion. After cooling, the foreign matter is found adhering to the silver near the point of contact of the metal with the support.

The following description from Mr. Crookes[3] gives the results of the researches of Prof. Stas on the production of pure silver from its chloride:

"All processes which depend upon the reduction of chloride of silver yield a metal containing copper and iron, unless indeed it has been redis-

[1] The same confusion which exists with regard to many other physical data, such as atomic weights and fusing-points, occurs in the case of the fusing-point of silver, which is variously stated by different authors as from 954° C. to 1037° C.

[2] Ganot, *Éléments de Physique.*

[3] *Select Methods in Chemical Analysis,* by W. Crookes, F. R. S.

solved three or four times successively in nitric acid, the solution, after diluting with twenty or thirty times its weight of water, being each time poured into aqueous hydrochloric acid, and the chloride of silver violently agitated in the liquid, as in the process of assaying. Experience has shown that chloride of silver free from copper and iron can be obtained directly by pouring a cold solution of nitrate of silver diluted with thirty times its weight of water into a slight excess of hydrochloric acid, washing the precipitate with cold distilled water, and then digesting the chloride, drying at the ordinary temperature, and finally powdered in aqua regia. When well washed after this treatment the chloride does not retain the slightest trace of either copper or iron, whilst so long as the chloride of silver is in a curdy form it retains in its pores, like coagulated albumen, some of the bodies which were dissolved in the liquid from which it was precipitated. Chloride of silver, however, when dried at the ordinary temperature and finely powdered, very easily yields to aqua regia foreign metals which contaminate it; but whatever may be the purity of chloride of silver, it produces a metal which always contains silicium and iron when it is reduced by Gay-Lussac's method; that is to say, by ignition with a mixture of chalk and charcoal. The presence of these foreign matters is easily ascertained by dissolving 100 grammes of silver in pure nitric acid in a platinum dish, and evaporating and fusing the nitrate. On dissolving the salt in cold water there is always a residue of silicic acid and sesquioxide of iron.

"M. Stas says that he has found as much as $\frac{15}{100000}$ths of silicium in silver reduced from the chlorides by Gay-Lussac's method. Chloride of silver purified by the above process, mixed with its own weight of pure, dry carbonate of sodium, containing a tenth part of pure nitrate of potassium, when heated in a white unglazed porcelain crucible with the precautions for avoiding intumescence, yields an ingot of silver.

"This ingot, fused again with a tenth of its weight of pure nitre and borax, and then run into an ingot-mould lined with pipeclay, gives a bar of silver which retains scarcely any appreciable traces of foreign matter. This process requires great care, for when the mixture of chloride and carbonate is heated, if the temperature is raised too much at first, the mixture fuses, bubbles up, and is in danger of running over.

"To effect with safety the reduction of chloride of silver in a white unglazed porcelain crucible, the latter should be placed inside a clay crucible. The most convenient plan for performing this operation is the following: Fill up the space between the two crucibles with calcined pipeclay powdered and mixed with 5 per cent. of fused and powdered borax. Under the influence of the heat the borax fuses and solders the whole together. When the chloride of silver is reduced the whole can be handled, and the melted silver poured out as if it were one crucible. The great bulk which has to be heated before reaching the porcelain crucible prevents its cracking and avoids loss of silver."

Alloys.—Silver by reason of its softness is not suited for most applications in the arts, and it is therefore necessary to alloy it with other metals to increase its hardness. For coinage, plate, etc. the requisite degree of hardness and toughness is obtained by the addition of copper, which can be alloyed with silver to a considerable extent without affecting its color. The coinage of the United States contains 10 per cent. of copper, the proportion of copper as well as silver being stated in thousandths; thus, pure silver being reckoned as 1000 fine, the fineness of coin or "standard silver" would be stated as 900 fine, the remaining

100 parts being copper. The later German and also the French silver coins are of the same grade; those of Great Britain are 925 fine, the remaining 75 parts consisting of copper. The alloy for plate and most articles of silver is about the same as that employed for coinage.

The alloy of platinum sometimes employed as a base for artificial dentures is described in the section on Platinum. For Von Eckart's alloy, which has been used in France for the same purpose, see p. 799. The alloys of silver with palladium, gold, and aluminum are described in the sections on those metals respectively.

The alloys of silver which are used as solders for that metal are chiefly composed of silver, copper, and zinc. The following compositions give good results:

	Parts.	Parts.
No. 1.	Coin silver, 90	Zinc, 10

This alloy may be used for soldering the platinum-silver alloy and for artificial dentures.

	Fine silver.	Copper.	Brass.	Zinc.
No. 2.	4	. .	3	
No. 3.	2	. .	1	
No. 4.	19	1	10	5
No. 5.	66.7	23.3	. .	10
No. 6.	50	33.4	. .	16.6
No. 7.	11	. .	4	1

The alloys above given may all be used for uniting surfaces of standard silver.

When it is required to solder articles of silver parts of which have already been soldered with a high-fusing alloy, it sometimes becomes necessary to use a solder which has a lower fusing-point than that of the solder first employed. The following alloys are suitable for this purpose:

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Medium fine silver, parts	7	16	3.5	2	48.3
Zinc "	1	1	1	1	16.1
Copper "	. .	. .	2.6	3	32.3
Tin "	. .	. .	. .	. .	3.3

Richardson in his treatise on mechanical dentistry recommends the following alloys as solders for silver plate used as a base for artificial dentures, either of which give good results:

	No. 1.	No. 2.
Silver	66 parts.	6 dwts.
Copper	30 "	2 "
Zinc	10 "	1 "

An alloy of silver $5\frac{1}{2}$ dwts. and brass wire 40 grains forms an excellent solder for the same purpose.[1]

In uniting the constituents of the foregoing alloys which constitute silver solders care must be taken to guard against loss of the volatile metals during fusion. This is easily accomplished by first fusing the silver, or silver and copper when the latter metal is a constituent, under a layer of borax or common salt, and when the metal is perfectly liquid

[1] *Dental Metallurgy*, Essig.

the zinc or brass may be added in rather small pieces to prevent chilling of the alloy. Or, still better, the method employed by Dr. Ambler Tees in the formation of his amalgam alloy may be pursued—viz. the volatile metals may be fused in a separate crucible under a protective flux and poured into the molten silver. The alloy when formed is poured into an ingot-mould and rolled into plate about No. 24 standard gauge.

The formation of alloys of silver and platinum presents no difficulties, as the two metals possess considerable affinity for each other, with strong indications of the formation of an alloy of definite proportions, the *modus operandi* being to introduce the platinum in the form of wire or small clippings into the fused silver. The operation may be conducted in an ordinary stove or melting furnace when the amount of platinum does not exceed certain limits; successive additions of platinum, however, increase the infusibility of the alloy, until a point is reached where the temperature required for its fusion is beyond the capacity of the ordinary melting furnace, and recourse must be had to the Fletcher blast-furnace or even the oxyhydrogen jet. While it is frequently stated that the platinum-silver alloy resists the action of sulphur compounds to a greater degree than the ordinary standard silver alloy, yet a case which occurred in the practice of the author seemed to disprove this: A gentleman who had been wearing an upper denture mounted on a plate of standard silver alloy for a number of years desired to have it replaced by another, the one he had been wearing being useless, having been bent out of shape and several teeth lost from it. He expressed a preference for a silver plate, but at the same time said that the only objection he had to it was its liability to tarnish, and the consequent difficulty of keeping it clean and bright. With the object of obviating the difficulty an alloy of fine silver with 15 per cent. of platinum was made and rolled into plate, from which a denture was constructed for him, and inserted with the assurance that the tendency to tarnish would be, if not entirely obviated, at least reduced to a minimum. After wearing the plate about six weeks, he returned with the complaint that the plate last made for him tarnished more readily than the first one, and that he could not possibly remove the stain. Upon examination the plate was seen to be covered with a thick film of what, to all appearances, was argentic sulphide, the stain upon the lingual aspect of the plate being much denser than upon its upper surface: in addition to this the lingual surface was rough and corroded. Those portions of the plate where the solder had flowed were only slightly stained and were perfectly smooth. A rather prolonged treatment of the plate with felt and brush-wheels covered with pumice restored a smooth surface, which was finally polished in the usual way with chalk and crocus-powder. In the course of about ten months he again returned with the plate in worse condition than before, perfectly black in appearance and riddled with numbers of fine holes, the whole plate being greatly reduced in thickness. As it was now useless, it was replaced by a denture of continuous gum. As every precaution was taken in the formation of the alloy by being repeatedly melted and cast to ensure a uniform mixture, and the metals employed as fine as could be obtained, and the amount of platinum in the alloy being known to be 15 per

cent., it is fair to presume that such a combination is not invulnerable to corrosive agents. A test of the salivary and mucous secretions of the patient with litmus revealed nothing abnormal in reaction.

The method employed in England of extracting the silver from the surface of this alloy by boiling sulphuric acid, and condensing the platinum left on the surface in a spongy condition by passing it through the rolling-mill, would no doubt overcome the difficulty arising from the action of sulphur compounds, as the surface of a plate so made consists of pure platinum simply, while the strength and elasticity of the core of platinum-silver alloy would give sufficient rigidity to the denture.

Many articles manufactured from standard silver have the copper extracted from their surface by first heating them to low redness, whereby the alloying copper is oxidized; this is afterward removed by submerging them in sulphuric acid, which dissolves the cupric oxide and leaves a superficial film of pure silver, giving the article a much whiter appearance, with a dead lustre which may be brought to a high state of brilliancy by burnishing. It is by this method that the so-called "frosted silver" is produced, the surface being left unburnished.

The function of silver, together with the extent of its use in alloys used as dental amalgams, has been described in the section on Amalgams. (See p. 806.)

Silver is applied as a superficial coating on a base of copper and some of its alloys in the production of various articles of use and ornamentation: the process is termed plating. Before the method of electro-deposition of metals became known silver-plated articles were made from a composite plate or sheet of metal obtained by casting an ingot of copper which was filed square and smooth, and placing upon it a piece of silver of the same area, but thinner, the two surfaces being perfectly clean. A little borax having been introduced between the two metals, they were bound together by iron wire and heated in a furnace to incipient fusion, by which they became firmly united, the process being somewhat similar to that of autogenous soldering. The composite ingot thus obtained was then rolled down in a heavy mill into plate, from which the various articles were manufactured. Silver plate of this description was known commercially as Sheffield plate, because Sheffield, England, was a principal seat of its manufacture.

By the method of electro-deposition articles of any size or shape can be readily and cheaply covered with a film of any desired thickness. For this purpose argentic chloride is dissolved in potassium cyanide solution or solution of sodium hyposulphite, or a simple solution of argentic cyanide in potassium cyanide may be used. In this the article to be plated, having been first rendered chemically clean, is suspended by a wire or rod and connected with the cathode or zinc element of a battery or other source of electricity. The anode or positive electrode terminates in a plate of silver, which is suspended in the same solution. When the circuit is thus closed, decomposition of the silver cyanide takes place, the silver being liberated at the negative pole and deposited upon the article to be plated suspended from it, while the cyanogen set free at the positive pole acts upon the silver plate which forms the

anode, gradually converting it into argentic cyanide, which dissolves. The quantity of silver dissolved from the anode is measured exactly by the amount deposited at the cathode. Thus the solution is always maintained of uniform strength and the operation is practically continuous.

Compounds of Silver.—Silver chloride, which occurs native as cerargyrite, has the formula AgCl. It may be produced by the direct union of silver and chlorine or by precipitation from solution of silver nitrate by a chloride. It forms under these conditions a white curdy mass which is insoluble in nitric acid, but may be dissolved in ammonium hydrate. By exposure to light it is decomposed into a subchloride with loss of chlorine, and becomes of a deep purple-black color, which gives it its importance in photography. In the presence of mercurous chloride the discoloration is prevented, or it may be restored to its original whiteness by the action of chlorine. By heating it may be fused to a translucent, crystalline sectile mass resembling horn. It crystallizes in the isometric system.

Silver chloride is extremely insoluble in water and dilute nitric or hydrochloric acids: when the latter are hot and concentrated, however, they dissolve an appreciable amount, which is again thrown down when the solution is diluted with water. Hot concentrated solutions of the alkaline chlorides all dissolve chloride of silver more or less. The use of sodium chloride in the metallurgy of silver has already been alluded to as a solvent for silver chloride. Silver chloride is also freely soluble in solution of potassium cyanide or sodium hyposulphite.

Three oxides of silver are known—viz. AgO, Ag_2O, and Ag_2O_2, the suboxide, the oxide, and the peroxide respectively. The only one of any practical importance is the oxide, Ag_2O. It may be prepared by adding a strong hot solution of argentic nitrate to one of potassium hydrate. It is this oxide which is formed by the combustion of silver at high temperatures. When dissolved in ammonia and the solution evaporated, the violently explosive compound known as fulminating silver is formed.

Silver nitrate, $AgNO_3$, is the most important salt of silver, and is obtained by acting upon the metal with dilute nitric acid: by evaporating the solution thus obtained the salt crystallizes in transparent orthorhombic prisms soluble in their own weight of cold water. They are readily fusible, and when cast into sticks are used in surgery as a caustic under the name of lunar caustic. In the presence of organic matter silver nitrate blackens, this property being made use of in the manufacture of certain hair-dyes and indelible inks.

Silver sulphide, Ag_2S, is found in nature as argentite, and is formed artificially by the direct union of sulphur and silver or as a precipitate when a soluble sulphide is added to a solution of silver. It is soluble in nitric acid, but is not acted upon by sulphuric or hydrochloric acid. The affinity of sulphur and silver for each other renders the latter unsuitable for the construction of artificial dentures with the vulcanized rubber attachment, as during the process of vulcanization combination of the free sulphur in the rubber with the metal of the plate will take place, completely corroding it by conversion into argentic sulphide. This action may, however, be entirely prevented by first coating that portion of the

plate which is to come in contact with the rubber with tin, which is easily accomplished by cutting a piece of pure tin-foil, No. 10 or even 20, to the shape of the surface of contact, which is first moistened with a solution of zinc chloride. The tin-foil is then burnished down in close contact with the plate, and the whole heated in the flame of a Bunsen burner until the tin melts and unites with the silver surface. Vulcanization may then be proceeded with without fear of affecting the silver plate, care of course being taken to protect the palatine portion of the plate, which has not been tinned, by the plaster investment.

Silver sulphate is obtained by boiling silver in sulphuric acid, as has been before alluded to; it has the formula Ag_2So_4, and is completely soluble in boiling water.

Detection.—The presence of silver in solution is easily recognized upon the addition of hydrochloric acid or a solution of any of the other chlorides, which is immediately followed by the formation in moderately strong solutions of a characteristic white curdy precipitate, which rapidly settles after agitation or stirring. The character of the precipitate may be verified by adding strong ammonia-water, in which it is completely soluble. The test is one of extreme delicacy, the merest trace of silver being shown by an opalescence of the solution upon the addition of hydrochloric acid or any soluble chloride.

Hydrogen sulphide or solutions of the alkaline sulphides produce in silver solutions a black precipitate of silver sulphide which is insoluble in potassium cyanide, dilute acids, or alkalies, but soluble in boiling nitric acid.

Potassium or sodium hydrate produces a brown or grayish-brown precipitate of silver oxide which is insoluble in an excess of the precipitant, but soluble in ammonia. Evaporation of the ammoniacal solution produces the silver nitride or fulminating silver, which is violently explosive. Potassium chromate yields a red precipitate of silver chromate, $Ag_2Cr_2O_4$, which is soluble in ammonia and concentrated nitric acid. Silver compounds heated with sodium carbonate before the blowpipe yield a button of metallic silver soluble in nitric acid and recognizable by its physical properties.

Determination.—The estimation of silver is usually accomplished by weighing its chloride, or by the volumetric assay with the standard solution of sodium chloride, or by the cupellation assay, which have already been described.

PLATINUM.

Symbol, Pt. Atomic weight, 197.6.

Platinum constitutes the most important member of a group of rare metals that are generally found associated in the ore—viz. platinum, palladium, iridium, osmium, rhodium, and ruthenium. Platinum was discovered by Anton Ulloa at Choco in Peru, S. A., in 1735. It is always found in the metallic state, generally in the form of flattened, irregular grains, often accompanied by grains of gold, and nearly always associated with the other metals of the platinum group. It is rarely

ever found in large nuggets, one of eighteen pounds weight, found in 1830 at Nischne-Tagilsk, Russia, being the largest on record. The largest quantities of platinum are found in alluvial deposits in the Ural Mountains. It is also found in Brazil, Peru, Borneo, Sumatra, Australia, and California.

Its name is derived from the Spanish *platina*, which signifies little silver, as it somewhat resembles that metal in color. It is stated that when it was first discovered much of it was thrown away, lest from its durability and high specific gravity it should be employed for debasing gold. The platinum ore is washed to remove earthy impurities, leaving behind the platinum metals, together with grains of gold, magnetic-iron ore, and corundum, as well as a very heavy alloy of osmium and iridium.

The relative amounts of the metals of the platinum group found associated in the ore are approximately as follows: Platinum, 50–80 per cent.; palladium, 2 per cent.; iridium, 7 per cent.; osmium, $1\frac{1}{2}$ per cent.; ruthenium, $1\frac{1}{2}$ per cent. A small amount of copper is often found in platinum ore. When any considerable quantity of gold exists, it is separated by amalgamation.

Two methods are used for the separation of platinum. The first, devised by Dr. Wollaston, was the only method known until 1859, when Deville and Debray published their method for the extraction and purification of platinum, since which time the Deville process has almost entirely superseded that of Wollaston, it being more economical and by it much larger quantities of ore can be treated. Wollaston's method, which is a chemical rather than a metallurgical process, strictly speaking, is described as follows by Bloxam and Huntington:[1]

"The grains of platinum ore are heated with nitric acid, which dissolves any silver, copper, iron, and lead in the form of nitrates; after these have been extracted the residue is washed with water and heated with hydrochloric acid, which dissolves the magnetic oxide of iron; it is then again washed with water, and gently heated for several hours with hydrochloric acid, to which a little nitric acid is added from time to time. The platinum is thus dissolved, together with palladium, rhodium, and some iridium, whilst the osmium and the rest of the iridium are left undissolved. The acid solution containing the chlorides of platinum, etc. is poured off, and the residue heated with fresh portions of acid as long as anything is dissolved when any quartz and corundum are left, together with the grains of the alloy of osmium and iridium, which are employed, on account of their surpassing all other metallic substances in hardness, for making the nibs of gold pens, upon which they are soldered.

"The liquid containing the chloride of platinum ($PtCl_4$) is mixed with a solution of sal ammoniac (muriate of ammonia) containing one-sixth of its weight of the salt, of which about four parts are employed for every ten parts of ore. A yellow precipitate is then deposited which contains the greater part of the platinum[2] in the form of *ammonio-chloride of platinum* —a combination of sal ammoniac with chloride of platinum. This yellow

[1] *Metals: their Properties and Treatment*, Bloxam and Huntington, p. 405.

[2] "Complete precipitation of the platinum as double chloride of platinum and ammonium is accomplished by evaporating nearly to dryness the acid solution of the chlorides obtained by digestion with aqua regia, and adding to it absolute alcohol previous to the addition of the ammonic chloride solution, which should be added only in sufficient quantity to ensure complete precipitation."

precipitate is washed with cold water, dried, and strongly heated in a plumbago crucible, when the sal ammoniac and chlorine are driven off, and *spongy platinum* is left as a gray porous mass. This is finely powdered in a wooden mortar, rubbed to a paste with water, passed through a sieve to render it perfectly uniform, and poured into a slightly conical brass mould closed below with blotting-paper wrapped around a steel stopper. When the water has drained off, a plunger is forced in by a coining-press so as to condense the mass, which has at first the specific gravity 4.3, until its specific gravity is 10, when it has been reduced to about two-fifths of its former bulk and has acquired a metallic appearance. The disk is now sufficiently coherent to be removed from the mould and intensely heated for about thirty-six hours in a porcelain kiln, when it contracts to about four-fifths of its former volume. It is taken out of the furnace at a white heat and hammered upon its ends, not upon its sides, lest it should crack. After being heated and hammered in this way several times the particles become thoroughly welded together in a compact, malleable mass of metal of specific gravity 21.5."

Before the discovery of the oxyhydrogen blowpipe, the credit for the invention of which is due to Prof. Robert Hare of the University of Pennsylvania, the process of welding platinum sponge was the only method known whereby the metal could be obtained in compact masses, as it is infusible at the highest temperatures of the blast-furnace; but in a specially constructed furnace of lime as much as 3200 ounces of pure platinum have been melted and cast into an ingot at one operation by means of the intense heat of the oxyhydrogen blowpipe.

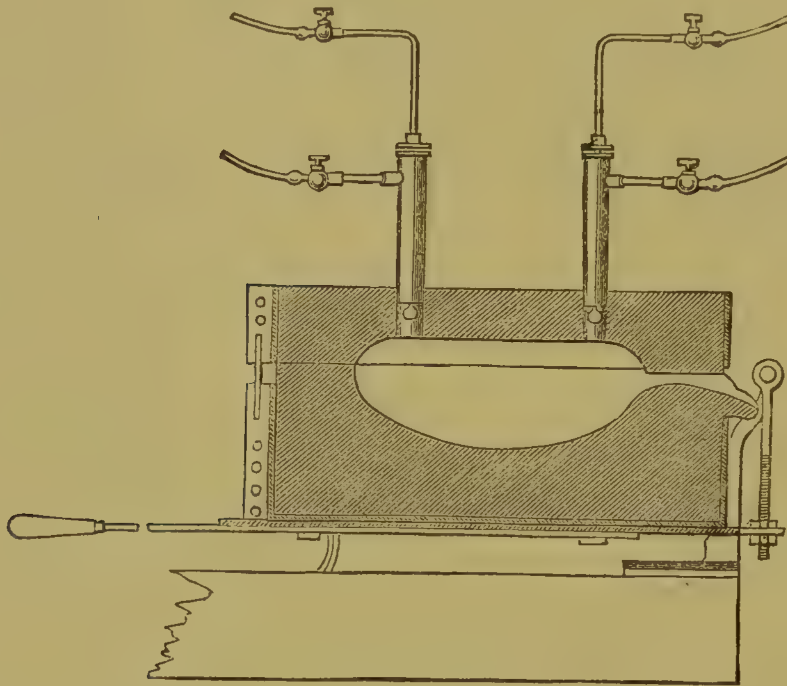
Deville's method for the extraction of platinum is based upon the solubility of that metal in melted lead, and is in some respects similar to one of the methods in use for the extraction of gold and silver, the metal being dissolved out of the ore by melted lead and afterward recovered by cupellation.

The platinum ore is mixed with an equal weight of native lead sulphide (galena), and thrown in small portions into the concave hearth of a small reverberatory furnace, where it is thoroughly stirred until all of the platinum is dissolved in the fused galena, after which a quantity of lead oxide (litharge) equal in weight to the amount of galena used is gradually added. The sulphur of the lead sulphide is oxidized to sulphurous anhydride at the expense of the oxygen of the lead oxide, and passes off as gas, while metallic lead is left, holding in solution the platinum; the alloy of iridium and osmium, being unaffected by the lead, sinks in separate grains to the bottom. After remaining at rest for some time the upper portions are ladled out and cast into ingots, while the residue is added to the next charge. The lead-platinum alloy is treated in a cupellation furnace, by which means the lead is all removed as oxide, leaving the platinum in a spongy state upon the cupel, from which it is transferred to the lime furnace and fused by the oxyhydrogen flame; during which operation any remaining lead, together with gold, silver, palladium, and osmium, is volatilized by the intense heat. When fusion is complete and all impurities have been volatilized, the metal is poured through an opening in the side of the furnace having a spout or gutter into a mould made of lime, gas carbon, or wrought iron lined with platinum. In this manner 25 pounds of platinum have been

melted and refined in three-quarters of an hour with the consumption of about 43 cubic feet of oxygen (Bloxam).

The furnace in which the fusion of platinum is performed (Fig. 301), and which in the treatment of platinum by Deville's method acts the part of both furnace and cupel, is constructed of thoroughly burned lime, and consists of two parts—the bed of the furnace, which is a large block of lime with a basin-shaped concavity formed in its centre,

Fig. 301.



with a trough or gutter leading from it to the outside, where it terminates in a lip or projection to facilitate pouring the fused metal. The cover of the furnace is a similar rectangular block of lime, with an excavation of the same general dimensions as that in the under block or bed, but much shallower. Through the top of the cover the oxy-hydrogen blowpipe passes by means of a conical perforation in the lime block. In the larger furnaces two such jets are used; they are usually made of copper tipped with platinum, and consist each of two tubes arranged concentrically, one within the other. Through the outer tube passes hydrogen or illuminating gas; oxygen is forced through the inner one. The flow of gas and temperature of the furnace are regulated by stopcocks. The melting operation is conducted by turning on the hydrogen first, which is ignited; the oxygen is then turned on. If it is simply intended to fuse scrap, the furnace is allowed to heat up first, and the pieces of platinum are dropped into the furnace through an opening at the side, when it quickly melts. In the treatment of the platinum sponge obtained by cupellation from the lead alloy by Deville's process, the charge is put into the furnace before it is heated. In this operation the lime performs to a certain degree the function of a cupel: the impurities remaining in the metal are oxidized and volatilized or absorbed by the lime of the furnace.

The temperature produced by the oxyhydrogen blowpipe has been estimated at 3000° C., and the effect of its contact with the lime and melted platinum is one of dazzling brilliancy, so that it becomes necessary for the workman to protect his eyes by means of smoked or dark-colored glasses during the operation of casting.

Platinum when melted resembles silver in its property of mechanically absorbing oxygen, which it evolves again at the moment of cooling to its point of solidification, exhibiting the phenomenon of *sprouting*.

As obtained by the process of Wollaston by welding the sponge, platinum lacks homogeneity. It is apt to blister or scale when rolled and hammered, fused platinum being free from this defect when pure. It is conceded that Wollaston's method of extraction yields a product more nearly approaching purity than that of Deville and Debray, notwithstanding that nearly all of the impurities are volatile at the temperature of the platinum furnace.

Properties.—Pure platinum is almost silver-white in color, with a tinge of blue or steel-gray, and is exceedingly ductile and malleable. It may be drawn into a wire of almost microscopic fineness by depositing a coating of silver upon a platinum wire and drawing this composite wire down to the size of the smallest hole in the drawplate, after which the silver coating is dissolved off by nitric acid, the resulting wire core being sufficiently fine for use instead of the spider web in the micrometer eye-pieces of microscopes. Dr. Arendt states[1] that a cylinder of platinum one inch in diameter and five inches long may be drawn into a wire sufficiently long to encircle the earth at the equator.

Platinum possesses a high degree of tenacity, being only surpassed in this respect by iron and copper. It can be readily rolled or beaten into foil, and is easily cut with the shears, owing to its softness. It is fusible only by the galvanic current or the oxyhydrogen blowpipe. Violle gives 1770° C. as its fusing-point. At a white heat it softens and may be welded. It is unalterable in the air at any temperature, and is not attacked by any single acid. Its specific gravity is about 21.5; Wagner[2] states the specific gravity at from 21 to 23. It is an imperfect conductor of heat and electricity. (See p. 793.) At high temperatures it absorbs hydrogen, and at a red heat is readily permeable by this gas. It combines directly with sulphur, carbon, arsenic, phosphorus, and silicon, and it is attacked by the fused alkaline hydrates potassa and soda.

Platinum possesses in a high degree the property of absorbing and condensing gases. If a thin sheet of platinum-foil be held in the flame of a Bunsen burner until it glows, and the flame be suddenly extinguished and the foil be allowed to cool even far below redness, upon turning the gas on again and holding the foil in the stream as it issues from the jet the foil will become hot, and after a moment will attain a temperature sufficient to ignite the jet of gas. This power of platinum to bring about combination of hydrogen and oxygen gases is exhibited in a much more marked degree when the metal is used in the finely-divided form of platinum sponge. As the surface presented for absorption of the gas is infinitely larger, the amount of gas absorbed is pro-

[1] *Anorganischen Chemie.* [2] *Chemische Technologie,* Johannes Rudolph Wagner.

portionately greater, and the action takes place much more rapidly; consequently a higher temperature is evolved.

In the still finer state of division known as platinum-black, obtained by dissolving the metal in melted zinc and removing the latter with sulphuric acid, its power to induce chemical combination is even more intense, for which reason it is used as an oxidizing agent. When freshly prepared and thoroughly dried, it will, when moistened with alcohol, cause it to ignite, or when its activity is somewhat impaired it will cause the oxidation of alcohol to acetic acid. By reason of its unalterability and its indifference to chemical reagents, as well as its great infusibility, platinum is of special value in the chemical laboratory for the manufacture of crucibles, stills, dishes, capsules, and various forms of chemical apparatus, as well as in chemical manufacturing industries for the production of apparatus for distilling and evaporating corrosive liquids.

Platinum has a low rate of expansion under increase of temperature, its coefficient being about the same as that of glass: for this reason it is used in the making of various kinds of philosophical apparatus, wires of it being directly attached by fusion of the glass around them. In dentistry it is used for the pins of artificial teeth and as the base of continuous-gum work, which without platinum would be an impossibility, its high fusing-point permitting the vitrification of the refractory porcelain body. Its low rate of expansion prevents any separation of the porcelain from its metallic base by changes of temperature. Its resistance to chemical action renders it absolutely free from corrosion by the fluids of the mouth, in which respect it is equal to fine gold. In the form of sponge it is employed as a pigment for imparting a bluish tinge to porcelain.

In combination with gold-foil it has been used in the form of foil as a filling material for carious teeth. Fillings made with it are very hard and have a good color, but as the foil is harsh and difficult to work under the plugger, much care is necessary in its insertion to ensure a moisture-tight filling.

Platinum unites readily with most of the metals. Alloyed with iridium, it is rendered harder, more or less rigid, and elastic—more infusible, and less readily acted upon by aqua regia. Iridium may be added up to 20 per cent. before the alloy becomes unworkable. Deville formed an alloy of 78.7 per cent. of platinum and 21.3 per cent. of iridium, which almost completely withstood the action of aqua regia. From 10 to 15 per cent. of iridium added to platinum greatly increases its hardness, elasticity, and resistance to chemical action, as well as increases its infusibility. In equal parts platinum and iridium form a brittle alloy, but capable of welding to a certain extent (Berzelius). The platinum-iridium alloy is extremely useful in strengthening partial lower dentures of rubber or continuous gum where the molars and bicuspids only are to be replaced. A strip of platinum-iridium alloy inserted in that portion of the plate which occupies the lingual aspect of the remaining natural teeth greatly adds to its strength.

With gold, platinum forms alloys of great value in the construction of artificial dentures. It confers upon gold greater hardness and

increased elasticity. 2 parts platinum and 1 part gold form a brittle alloy; in equal parts the alloy of gold and platinum is malleable. With 7 parts gold and 3 parts platinum the alloy was found by Prinsep to be infusible in the strongest heat of a blast-furnace; the addition of more gold increased its fusibility. "1 part platinum and 9.6 parts gold yield an alloy of nearly the same color as gold, with a density very close to that of platinum" (Clarke). 11 parts gold and 1 platinum yield, according to Hatchett, a grayish-white alloy having somewhat the color of tarnished silver.

The elastic alloy of gold and platinum is of particular service, and is indeed essential, in the manufacture of clasps, stays, and springs for artificial dentures. Richardson gives several formulas for such alloys. (See section on Gold.)

Platinum in the spongy form unites with mercury to form an exceedingly unctuous amalgam. Union of the metals does not take place rapidly, and only after continuous rubbing in a warm mortar. Platinum amalgam is used to coat other metals with platinum by a process precisely similar to that employed in fire-gilding.

With cadmium, platinum forms a definite alloy containing about 54 per cent. of cadmium and 46 per cent. of platinum—therefore nearly of the formula $Pt.Cd_2$—which is a silver-white, very brittle, and fine-grained alloy (Stromeyer). 2 parts antimony and 1 part platinum sponge unite with vivid incandescence. When fused the alloy is brittle, fine-grained, and steel-gray in color.

Bismuth and platinum sponge in the same proportions as the above unite, but without incandescence, to form a brittle, easily-fusible, bluish-gray alloy with a laminated fracture (Gehlen).

Copper and platinum do not unite below a white heat; equal parts, fused together by the oxyhydrogen blowpipe, form a pale-yellow, gold-colored alloy having the same specific gravity as gold, but which tarnishes in the air (Clarke).

With lead and tin, platinum unites in all proportions; alloys of the former metal are harder, tougher, and whiter than pure lead. The tin-and-platinum alloys are hard and brittle, with comparatively low fusing-points. The union of tin and platinum sponge takes place with incandescence.

Silver and platinum appear to unite in definite proportions, the definite silver-platinum compound being dissolved in excess of silver. The alloy when slowly cooled has a tendency to separate into two or more alloys, those richer in platinum occupying the lower portion of the ingot by reason of their greater specific gravity. Platinum when alloyed with silver renders it harder and more elastic, and increases its resistance to the action of sulphur and its compounds. Such an alloy is used in England as a base for artificial dentures in preference to coin silver, because of its greater elasticity and resistance to chemical action. When this alloy is boiled with concentrated sulphuric acid, the silver is removed from the surface, leaving a superficial coating of pure or nearly pure platinum, which is condensed by passing it through the rolling mill. Nitric acid dissolves both platinum and silver when they are alloyed, and the former metal is present to an amount not exceeding 10 per cent. of the total weight of alloy.

The use of platinum as a constituent of dental amalgam alloys has already been noted. (See section on Amalgam Alloys.) The proper solder for platinum is fine gold, by means of which an exceedingly firm union is obtained. The union is weaker in direct proportion as the gold used for solder is debased by alloying.

Platinum Compounds.—Oxygen forms two compounds with platinum—platinous oxide, PtO, and platinic oxide, PtO_2. The first is obtained as a black hydrate by decomposing platinous chloride with potassa and neutralizing the solution with dilute sulphuric acid. It is a weak base, which forms salts with acids. It is readily decomposed by heat. Platinic oxide is formed by boiling platinic chloride with an excess of sodic hydrate and neutralizing with acetic acid. This oxide is also a weak base, but sometimes plays the part of an acid, forming when boiled with the alkali hydrates a series of salts called platinates. If this oxide be dissolved in dilute sulphuric acid and ammonia added in excess, a black precipitate of fulminating platinum is obtained, which is a combination of water with a double molecule of ammonia, in which four atoms of hydrogen are replaced by one tetrad atom of platinum; thus:

$$N_2H_2Pt^{iv}4H_2O.$$

When heated this compound of platinum explodes violently.

Chlorine forms two compounds with platinum—platinous chloride, $PtCl_2$, and platinic chloride, $PtCl_4$. The first is a dark-green powder insoluble in water and sulphuric and nitric acids, but soluble in sodium and potassium hydrates. It is prepared by heating platinic chloride to 230° C. until chlorine ceases to be given off. Platinic chloride, the most important compound of platinum, is prepared by dissolving the metal in aqua regia, assisted by gentle heat, and evaporating the solution to dryness upon a water-bath. It forms under these conditions a red-brown mass of deliquescent crystals easily soluble in water and alcohol. This compound forms double salts with the chlorides of the alkali metals.

The sulphides of platinum, PtS and PtS_2, are formed by the action of hydrogen sulphide upon platinous and platinic chlorides respectively. They are brownish-black powders.

Detection of Platinum.—Hydrogen sulphide yields in platinum solutions a brown precipitate of platinic sulphide, insoluble in hydrochloric acid, but soluble in ammonic sulphide. Potassium chloride gives a crystalline yellow precipitate of potassium-platinic chloride. Zinc and iron precipitate the finely-divided metal. Heated on charcoal before the blowpipe, the metal is reduced.

Platinum is estimated by precipitation with ammonic chloride and igniting the double salt thus formed, the metal being weighed as spongy platinum, which constitutes 44.30 per cent. of the salt.

Iridium.

Symbol, Ir. Atomic weight, 192.7.

The irregular flattened metallic grains and scales which are found in the residues after the extraction of platinum from its ores consist of a

native alloy of iridium and osmium, the so-called *iridosmine.* The metal is obtained from this native alloy by mixing it with sodium chloride, and conducting chlorine gas over this mixture contained in a heated glass tube. The mixed sodio-chlorides of iridium and osmium thus formed are dissolved in water, evaporated, and distilled with nitric acid, which removes the osmium as osmic acid: when its complete removal is thus effected, ammonium chloride is added to the residual solution, which precipitates the ammonio-chloride of iridium as a dark red-brown precipitate. From this, spongy metallic iridium is obtained by ignition in a manner precisely similar to the production of spongy platinum.

Iridium is nearly white in color, exceedingly hard, brittle, and fusible only by the compound blowpipe. When thus fused it has a specific gravity of 22.4 and is insoluble in all acids. When heated in the air, spongy iridium oxidizes to the sesquioxide, Ir_2O_3, which is a black powder used for imparting an intense black to porcelain. Alloyed in small amount with gold, the product is still malleable, and the color of the gold is not greatly impaired. When such an alloy is acted upon by aqua regia, the gold is dissolved as auric chloride, while the iridium is left as sponge.

The platinum alloys of iridium are treated of in the section on Platinum.

Böttger formed an amalgam with iridium by immersing sodium amalgam in an aqueous solution of chloriridate of sodium: he describes the amalgam as soft and viscid.

The chlorine compounds of iridium, $IrCl_2$ and $IrCl_3$, form compounds with the alkaline chlorides analogous to those of platinum. It also forms compounds with oxygen, sulphur, and iodine. The varied colors of its compounds suggested the name of the metal, which is derived from Iris, the rainbow.

Detection of Iridium.—Ammonium chloride throws down a dark red-brown precipitate of iridio-chloride of ammonium, which consists of microscopic octahedra. Stannous chloride gives a light-brown precipitate in iridium solutions. Potassa added in excess to a solution of iridio-chloride of sodium decolorizes it, while some iridio-chloride of potassium is thrown down. On heating the solution, and then exposing it for a considerable time to the air, it first acquires a reddish and afterward an azure-blue color, which serves as a characteristic distinction from platinum. On evaporating the solution to dryness and treating with water a clear liquid and blue residue are obtained.

"With the exception of alloying with platinum, the principal use of iridium up to the present time has been for pointing gold pens. The 'iridosmine,' called by the manufacturers, 'diamond point,' consists simply of a grain of iridium soldered on the point of the pen, which is afterward sawed in two to make the two nibs, and ground into proper shape. For preparing larger pieces of iridium than found in nature for making points for the Mackinnon stylographic pen, Mr. John Holland of Cincinnati has devised the following ingenious process: The ore is heated in a Hessian crucible to a white heat, and after adding phosphorus the heating is continued for a few minutes. In this manner a perfect fusion of the metal is obtained,

which can be poured out and cast into any desired shape. The material is about as hard as the natural grains of iridium, and, in fact, seems to have all the properties of the metal itself.

"Phosphor-iridium, as this metal may be called, possesses some very remarkable properties. It is as hard as, if not harder than, the iridosmine from which it is prepared. It is somewhat lighter, owing to its percentage of phosphorus and increase of volume. It is homogeneous and easy to polish, and forms some alloys impossible to prepare in any other manner. It combines with small quantities of silver, and forms with it the most flexible and resisting alloy of silver. Added in small quantities to copper, it furnishes a metal possessing very small resistance to friction, and especially adapted for articles subjected to great pressure.

"With iron, nickel, cobalt, and platinum, phosphor-iridium forms combinations in all proportions. With iron an alloy is obtained which retains the properties of phosphor-iridium, although its hardness decreases with a larger addition of iron. The alloy is slightly magnetic, and is not attacked by acids and alkalies, and the best file produces no effect upon it even if it contains as much as 50 per cent. of iron. With more than 50 per cent. of iron the power of resistance decreases gradually, and the nature of the metal approaches that of iron. In casting phosphor-iridium it is observed that the mould fills up better after a second and third fusion.

"By fusing the phosphor-iridium several times a part of the phosphorus evaporates and the melting-point becomes higher. If heating is continued too long, the metal does not fuse, and phosphorus must be added in order to give it its former properties. The process of removing the phosphorus after casting is as follows: The metal to be dephosphorized is placed upon a fire-resistant bed upon the bottom of the crucible and surrounded with powdered lime, and then heated for some time to a red heat. The phosphorus combines with the lime, and forms a green slag which collects upon the bottom of the crucible. The temperature is gradually raised until the metal is completely dephosphorized."[1]

Palladium.

Symbol, Pd. Atomic weight, 106.5.

Palladium, besides occurring as a natural congener of platinum in its ores, is found alloyed in some specimens of Brazilian gold and in some selenium ores. It closely resembles platinum in color, lustre, and malleability. It differs from platinum in density, its specific gravity being but 11.8—a little more than one-half as great as that metal. Its melting-point is about the same as that of pure iron, 1600° C. Before reaching its melting-point, however, it softens and may be welded. It is distinguished from platinum by being more readily oxidized and by its attraction for cyanogen, with which it forms an insoluble compound. The metal is obtained from the aqua-regia solution of platinum ore after the greater part of the platinum has been precipitated as platinum-ammonium chloride by sal ammoniac. For this purpose the filtrate from the double salt of platinum and ammonium is neutralized with sodium carbonate, and a solution of mercuric cyanide is added which throws down a yellowish-white gelatinous precipitate of palladium cyanide. This salt upon ignition to bright redness yields metallic palladium in

[1] *Techno-chemical Receipt-book*, Brannt-Wahl.

a form similar to spongy platinum, which may then be fused or welded into compact form. It is somewhat darker in color than platinum, and when heated to dull redness with free access of air it becomes coated with a bluish film of oxide, but regains its brightness and metallic lustre upon more intense ignition, the oxide being decomposed, or by suddenly chilling it in cold water.

Palladium is difficultly soluble in nitric acid, but dissolves somewhat more readily in nitric acid containing nitrous acid. It dissolves sparingly in boiling concentrated sulphuric acid to form palladious sulphate, $Pd.SO_4 + 2H_2O$. Its best solvent is nitro-hydrochloric acid, which converts it into palladic chloride, $Pd.Cl_4$; this compound forms double salts with potassium or ammonium chloride which are difficultly soluble, similar to the corresponding platinum compounds. On evaporating the solution of palladic chloride it decomposes with evolution of chlorine to palladious chloride, $PdCl_2$, yielding a brown mass of deliquescent crystals which form easily-soluble double salts with potassium and ammonium chloride.

Palladium is more readily acted upon by iodine than is platinum. A drop of tincture of iodine let fall upon the surface of a strip of palladium-foil and evaporated over the flame of a spirit-lamp leaves a black stain, which does not occur when platinum is similarly treated; which fact serves as a rough means of distinguishing the two metals.

Palladium possesses in a remarkable degree the property of absorbing or occluding hydrogen. According to Graham,[1] the "hammered palladium-foil condenses six hundred and forty times its volume of hydrogen below 212° F., though it has not the power of absorbing oxygen or nitrogen. Foil made from fused palladium absorbs only sixty-eight times its volume of hydrogen."

According to Debray, when water is decomposed by the electric current, palladium-foil being used as the negative electrode, the liberated hydrogen is absorbed by the palladium to the amount of 960 volumes; the metal expands one-tenth its volume, and becomes specifically lighter, but entirely retains its metallic appearance. Debray regards the combination of hydrogen and palladium under these conditions as an alloy which has the composition Pd_2H. Upon heating the palladium hydride to 100° C. *in vacuo*, all of the hydrogen escapes as gas. Palladium hydride is a powerful reducing agent by virtue of its hydrogen, which is liberated from it in the nascent state.

Alloys.—In the finely-divided state it unites readily with mercury to form an amalgam, which is probably a chemical compound (see section on Amalgams), as the union is attended with considerable elevation of temperature, and under certain conditions with a suddenness that causes, according to Mr. Coleman,[2] an explosion of the mass with emission of light. Mr. Fletcher states that palladium may be prepared to combine with mercury so as to set quickly or slowly by varying the strength of the solution of palladious chloride from which it is precipitated by metallic iron or zinc, but its value as filling material is destroyed unless setting takes place rapidly. The fillings fail unless fully hard in

[1] *Proceedings Royal Soc.*, June, 1866.
[2] *Dental Surgery and Pathology*, p. 188, Am. ed.

so short a time that the amalgam is difficult to insert whilst it remains plastic.

The directions given by Mr. Coleman for the preparation of palladium amalgam are as follows:

"About as much mercury as would fill the cavity to be treated is placed in the palm of the hand, and the palladium powder very gradually added. It requires some careful rubbing with the forefinger before the two become incorporated, when it should be divided into smallish pellets, and these rapidly carried one after another to the cavity, each piece being well compressed and rubbed into the inequalities of its walls by a burnishing or compressing instrument and with a rotary movement of the hand. This is continued until the cavity is quite filled, or even, if necessary, to some slight extent built out, the surface being rendered smooth and polished with the burnisher until it has quite set, which is generally in a very little (too short) a time."

Mr. Coleman further states that this is probably the most durable of all amalgams, but the most difficult to manipulate. Its surface changes to a black color, but as a rule it does not stain the structure of the tooth.

All the alloys of palladium are harder and more brittle than the pure metal. Silver and palladium form a very tough and malleable alloy, suitable for the graduations of mathematical instruments, as it is susceptible of a high polish and does not easily tarnish. This alloy has also been used in France as a base for artificial dentures. With silver and copper, palladium forms a very elastic and springy alloy which has been used for toothpicks, inoculating lancets, the points of pencil-cases, etc.

Mr. Fletcher produced a number of alloys of palladium, silver, and tin in different proportions, and tested their properties when amalgamated with a view to ascertaining the value of palladium in dental amalgam alloys, but the results obtained were so unsatisfactory that the subject was abandoned by him.

Gold and palladium form a hard alloy in which the color and malleability of the gold are impaired in proportion to the quantity of palladium in the alloy.

Palladium combines with antimony, bismuth, zinc, tin, iron, and lead, forming very brittle alloys. With nickel it forms malleable alloys which are susceptible of high polish (Thomas Fletcher).

By reason of its lightness, hardness, and resistance to corroding influences, palladium fulfils the requirements of a metal for use as a base for artificial dentures; but its high price, owing to its scarcity, prohibits its use for that purpose at present. Formerly, there existed a pretty abundant source of this metal in the form of an alloy with gold found in the mines of Brazil, but of late years this has failed and palladium has risen to an extremely high price.

Palladium forms two classes of compounds—palladious, Pd'', and palladic, Pd^{iv}—with chlorine, oxygen, and sulphur, the former of which are the more stable.

Detection—Mercuric cyanide produces a yellowish-white gelatinous precipitate of palladious cyanide from the solution of palladious chlor-

ide, which is soluble in hydrochloric acid and in ammonia, and which yields the metal upon ignition. Potassium iodide yields a black precipitate of palladium iodide under the same circumstances. Both of these reactions are characteristic.

Iron.

Atomic weight, 56. Symbol, Fe'' (Ferrum).

The compounds of iron are widely distributed throughout nature and in great abundance, being present in all forms of rock and earth, to which they impart various shades of color, it being the commonest natural mineral coloring material. It is found in plants and in animal tissues, and is present in the coloring matter of the blood, of which it constitutes about 0.5 per cent.

With respect to its usefulness, it occupies the first place among the the metals. Its great abundance and the comparative readiness with which it can be smelted from its ores, together with its cheapness, give it a position of great economic importance in the arts of construction. Its great strength and relatively low specific gravity of from 7.5 to 7.84 make it valuable as a building material and in the construction of marine vessels. When first extracted from its ores in the form of cast iron it is comparatively fusible, but by subsequent treatment and conversion into wrought iron it becomes the most infusible of the common metals, in which form is developed to the highest degree the property of welding, by which two surfaces, softened by heat, can be forged together into a homogeneous mass without melting. It may be made into castings which can be readily cut, filed, or bored, or by proper treatment into castings which will resist the action of any metallic tool. By suitable processes cast iron as extracted from the ore may be converted into steel, the strongest as well as most elastic metal known, and from which tools are made for the working of all other metals and materials. It is the only metal which is adapted for the manufacture of the magnetic needle of the compass, as well as for the magnets of magneto-electric and electro-magnetic apparatus. Its ductility and malleability render it capable of being drawn into the finest wire or rolled and hammered into thin sheets.

Iron seems to have been known from the earliest ages, and while it is generally conceded that a knowledge of bronze existed prior to that of iron, yet indisputable evidence exists that a knowledge of the manufacture of the latter metal existed at least two thousand years ago (Bloxam).

Iron is rarely found in a metallic state in nature, nearly all the specimens found being in irregular masses which have descended upon the earth's surface, their origin being unknown. They are termed meteorites, and consist mainly of iron associated with varying quantities of nickel, sometimes with other metals, and usually with phosphorus, carbon, and sulphur in addition. These masses of meteoric iron vary from a few grains to a number of tons in weight.

Iron is commonly found associated with oxygen or sulphur in a state of chemical combination, and while the oxide of iron—or iron rust, as it

is familiarly known—enters largely into the composition of nearly all rocks and clays, to which it imparts more or less of a red or brown color, they are not considered as ores of iron except when iron is present to the amount of at least 20 per cent., a smaller quantity not being profitable to work.

The compounds constituting the ores from which iron is principally obtained are its various native oxides and carbonates—viz. magnetite, red and brown hæmatite, specular ore, spathic iron ore, clay iron-stone, and black-band ore, the last three containing carbonic acid and the others being oxides. As reduced from its ores by the ordinary smelting processes, iron is never pure, but contains variable amounts of carbon, silica, phosphorus, sulphur, etc., which modify its physical properties to a remarkable extent; in fact, the whole series of modifications in which this metal is used, from wrought iron, which is soft and malleable, to cast iron, which is hard and brittle, and which form the extremes, with various grades of steel tough and elastic standing in an intermediate relation, are all the results of variations in the relative proportions which the impurities named bear to the amount of iron.

Pure iron is prepared by heating its chemically pure oxide or oxalate in a current of hydrogen. In compact masses pure iron has a grayish-white color, is tolerably soft, and oxidizes but slowly in the air. Its specific gravity is 7.78. In moist air ordinary iron rusts rapidly, and is converted into ferric oxide. Iron decomposes water at a red heat, depriving it of its oxygen and liberating hydrogen. It dissolves readily in hydrochloric, sulphuric, and nitric acids, in the two former with liberation of hydrogen, in the latter nitric oxide is evolved. It is also attacked by chlorine, bromine, and iodine. Oxidation of iron is retarded or prevented by contact with a more electro-positive metal, such as zinc; hence the practice of coating the metal with zinc, or galvanizing it, for certain uses. The fusing-point of pure iron is estimated to be about 2900° F. or 1600° C.; it requires a bright white heat to melt it.

When rolled or drawn into wire it has a fibrous texture, upon the perfection and character of which depends much of its tenacity and toughness.

Three distinct grades or modifications of iron are recognized—viz. cast iron, wrought iron, and steel. Between these a large number of varieties are produced, all closely related and shading imperceptibly into each other, due to variations in the percentage of carbon, etc. which the metal contains.

As first produced in the blast-furnace, iron is found to have combined with a considerable amount of carbon, about 4.5 per cent. being the maximum. A portion of this exists in chemical combination with the iron as a carbide, the remainder being simply dissolved in the form of graphite. Iron also dissolves and combines with other substances which were originally present in the ore and fuel, which have an important bearing upon its physical qualities. These are principally phosphorus, silicon, sulphur, manganese, etc.; but it is the quantity of carbon contained in the iron which exerts the greatest influence upon its quality and physical properties.

Cast iron which contains the maximum amount of carbon is the most fusible variety, and is hard and brittle; its fractured surface is usually whitish or grayish in color and distinctly granular or crystalline in texture. It has a specific gravity of about 7.1, and fuses at about 1200° C. It passes from the solid to the liquid condition without previous softening, and cannot therefore be welded or forged. By reason of its fluidity when melted, and its comparatively low fusing-point, it is particularly adapted to the manufacture of castings. Analysis of upward of a hundred specimens of cast iron showed carbon from 4.81 to 1.04 per cent.[1]

Wrought iron is the purest commercial form of iron, and contains the least amount of carbon. It is produced from cast iron by eliminating nearly all of its carbon and other impurities. The process by which this is accomplished is termed *puddling*, and consists in melting pig or cast iron in a reverberatory furnace with a certain amount (about 20 per cent.) of iron scales or black oxide of iron, Fe_3O_4, which gives up its oxygen after a time to the carbon and other impurities, converting them into oxides and leaving the iron nearly pure. As the process approaches termination the fusing-point of the mass grows higher, and the pure iron in a soft or pasty condition is collected into large irregular masses or balls upon the end of an iron bar by the workman, and worked into as compact a condition as possible, after which it is passed through a series of powerful rollers which squeeze out the more fusible slag entangled in it and convert it into bars. A number of these *rough bars* are afterward piled together and passed at a welding heat repeatedly through rollers until all of the remaining slag is forced out and the metal becomes tough and fibrous; in which condition it is nearly pure and differs greatly in its properties from cast iron. Its fusing-point has been raised beyond that required to melt steel; its specific gravity is increased; it is much softer than cast iron; toughness has been developed, and its texture is laminated or fibrous, very compact and tenacious, and an entirely new and remarkable property has been developed—viz. the quality of becoming soft or pasty previous to fusion, by virtue of which two pieces similarly heated can be forged or welded together; a property of great value in the working of this variety of iron when its high fusing-point is considered. The effect of *puddling* upon the cast iron has been to reduce the amount of its carbon from 4 or 5 per cent. to from 0.3 to 0.1 per cent., with even a greater relative reduction in the amounts of phosphorus, silicon, sulphur, etc.

Intermediate, as regards chemical composition, between the varieties of iron just considered is that known as steel. Perhaps the one quality which most strongly characterizes steel is its property of becoming extremely hard and brittle when suddenly cooled after being heated to redness, though the difference in composition and physical properties between a low carbon steel and wrought iron rich in carbon on the one hand, and a high carbon steel and cast iron low in carbon on the other hand, is so slight that it is extremely difficult to draw any distinctive line between them. "It has been found, however, that iron does not become decidedly steely in its nature until it contains as much as 0.15 per cent. of carbon. When the carbon in steel amounts to as much

[1] Percy, *On Iron and Steel.*

as 1.4 per cent., it begins to acquire the properties of white cast iron" (Bloxam).

Though up to within a recent period it was customary to designate as steel only such iron containing carbon as was capable of being hardened and tempered, yet since the introduction of the Bessemer and open-hearth processes the metal produced by these is included in the term "steel;" but much of it is of such a low degree of carburization that it cannot be appreciably hardened or tempered. It may be safely stated, however, that metal containing less than three-fourths of 1 per cent. of carbon is not usually employed where it is intended to harden, and, on the other hand, $1\frac{1}{2}$ per cent. is perhaps the maximum amount contained in any steel that can be safely worked.

Two distinct kinds of processes are used for the production of steel. The first of these accomplishes the desired result by increasing the amount of carbon in wrought iron until it is converted into steel. The second is the reverse of this, and consists in removing from cast iron a portion of its carbon and the greater part of its other impurities, leaving a sufficient amount of carbon in combination with the iron, thereby producing steel. It will be seen that the addition of about 1 per cent. of carbon to wrought iron will convert it into steel; this is done by the process of *cementation*. Bars of iron are imbedded in charcoal coarsely powdered, and subjected to a high temperature for several days in a fire-brick chest, a number of tons of bar iron being treated at one time. The heating is continued for from six to ten days, after which the charge is slowly cooled. When withdrawn from the chest the bars are found to be covered with blisters, and their fractured surfaces show a finely granular instead of the fibrous texture which they previously possessed. Chemical analysis shows that the iron has taken up about 1 per cent. of carbon, which has penetrated the whole structure of the bar. In this condition it is far from homogeneous in composition, and is called *blister steel*. Uniformity of composition is secured by subjecting bundles of the carbonized bars to repeated blows from a tilt-hammer at a welding heat. After this treatment it is termed *shear steel*, and is fitted for the making of shears, files, and other tools. Perfect homogeneity is best obtained, however, by melting the blister steel and casting it into ingots; when thus treated it is termed *cast steel*.

A process analogous to cementation is used for converting the external surface of certain articles forged from bar iron, such as gun-locks, into steel when great superficial hardness, combined with the toughness of wrought iron, is required. This is done by heating them in contact with some substance containing carbon (bone-dust, potassium carbonate, or potassium ferrocyanide), and afterward chilling them in water. The process is termed *case-hardening*, the small quantity of carbon absorbed by the metal during the operation converting it superficially into steel. Conversely, small articles made from cast iron have their malleability and tenacity increased by heating them for a time in contact with the oxide of iron or manganese; the excess of carbon and silicon is removed by oxidation from the surface through conversion into carbonic oxide and silica, while the cast iron is converted into *malleable iron*.

The Bessemer process for the production of steel consists in blowing

atmospheric air through a quantity of molten cast iron contained in an apparatus termed a *converter*. From three to ten tons are operated upon at a time. The action of the blast upon the metal is to oxidize the carbon, silicon, and manganese. Sulphur and phosphorus are difficult of removal by this process; hence the necessity for employing ores as free as possible from them. The combustion of the carbon contained in the cast iron is attended with great elevation of temperature, so that the metal is maintained in a fluid condition throughout the operation solely by the energy of the reaction in the converter. Originally, it was customary to arrest the action of the blast as soon as the amount of carbon was reduced to about 1 per cent. Now, however, it has been found that steel of a better quality can be produced by continuing the purification until nearly all of the carbon is removed and liquid bar iron remains in the converter, and adding to this, before pouring into the moulds, the proper amount of carbon in the form of a peculiar kind of white cast iron known as *Spiegeleisen* (mirror iron), which contains large proportions of combined carbon and manganese: a similar compound called ferro-manganese is used for the same purpose.

Steel produced by the Bessemer process has largely supplanted iron in many of its applications, it being used for the manufacture of rails, armor-plates for vessels, girders, etc., in the construction of edifices and bridges, the manufacture of machinery, tools, etc. This process, by reason of its perfection, simplicity, and immense importance as a factor in the growth of communities and of human progress in general, must stand pre-eminent as the grandest metallurgical discovery ever made.

In addition to carbon, it has been seen that steel may contain variable amounts of other substances—viz. sulphur, phosphorus, silicon, and manganese. These exert a marked influence upon its quality. Sulphur, when present in as small a proportion as 0.10 per cent., renders the metal what is technically termed *red-short*—*i. e.* brittle and liable to fracture when rolled or worked at a red heat. It also impairs the soundness of castings.

Phosphorus has the reverse effect, rendering the steel brittle when cold, or, as it is termed, *cold-short*. Phosphorus and sulphur tend to neutralize each other's effect when present in the same steel. The hardening quality of phosphorus is believed to be greater than that of carbon upon steel. Unlike carbon, however, the hardening effect of phosphorus upon steel is not influenced by the rate of cooling of the metal—a peculiarity which makes it a very objectionable element in steel intended for cutlery or tools, as it renders them extremely difficult to temper, even 0.25 per cent. making the production of a fine cutting edge impossible. In the manufacture of castings a small amount of phosphorus is rather beneficial, as it renders the metal more fluid when molten and does not materially reduce its strength.

Manganese is believed to aid in the elimination of phosphorus and sulphur as well as of oxygen, and by increasing the fluidity of the slag facilitates its complete removal.

Chromium and tungsten in small quantities have been added to steel for the production of certain qualities for special application. The former produces a fine-grained metal when present in small quantity,

and greatly increases the hardness. An excess renders it brittle. Tungsten also exerts a marked hardening influence upon steel, without the necessity of tempering. Both alloys have been used for the manufacture of dental instruments and tools for turning and cutting very hard metal; their applications are as yet limited.

Hardening and Tempering Steel.—While each of the substances commonly occurring in steel—viz. carbon, silicon, phosphorus, and manganese, as well as a few other elements which may be looked upon as accidental impurities—greatly modify the physical characteristics which make it especially valuable, none exert so important an influence as carbon. This element is present in steel in two conditions, a portion being in chemical combination with the iron as a carbide of iron, and the remainder simply held in solution, as graphite. It has been recently shown that the proportion of combined carbon within certain limits bears a direct relation to the tensile strength of the metal, variations as minute as one hundredth of 1 per cent. making considerable alteration in this quality. The same is true of hardness, the effect of carbon up to a certain point being to increase tenacity and decrease ductility, and also to cause the metal when heated and suddenly cooled to become more or less hard, the hardening being in direct proportion to the amount of carbon present and the rate of cooling. As before stated, 1.5 per cent. of carbon is about the maximum amount contained in steel that can be worked, great care being necessary in working a highly carburized steel to prevent over-heating or burning it, a cherry-red heat being the maximum temperature at which it is safe to work it. A high-carbon steel is used for the manufacture of razors and tools for cutting hard metal. From 1 to $1\frac{1}{4}$ per cent. of carbon constitutes the amount in steel used for most tools. A 1-per-cent. steel is extremely useful, as it can be readily welded, and the unhardened portion of the tool may be made tough, so that it will withstand the percussive force of a hammer without chipping: cold-chisels are made of this class of steel.

A proper amount of elasticity and toughness for some purposes is imparted to steel by a process of hammering, independently of the method of hardening in water and *letting down*, as it is termed, by reheating. Steel when cast into bars or ingots exhibits a more or less finely crystalline or granular appearance when a fractured surface is examined. The effect of repeated blows from a hammer, properly applied, is to convert the texture of the metal from this crystalline condition into a more or less fibrous structure, having greater tensile strength as well as toughness and elasticity. This is brought about by a condensation of the particles of metal and the development of its fibrous condition. A reduction of volume and an increase of specific gravity also result from this treatment. The degree of temper developed by this process of *hammer-hardening* renders the steel sufficiently elastic for a number of purposes, as the manufacture of certain kinds of springs, etc.

The process commonly employed for developing the maximum elasticity and toughness of steel, however, consists in suddenly chilling the metal from a highly-heated state, by which the highest degree of hardness is produced. Conversely, hardened steel when

heated to redness and allowed to cool slowly becomes extremely soft: any desired variation between these extremes may be obtained by first rendering the metal *full hard* by heating to redness and suddenly chilling it, and then carefully reheating it to the proper point at which the desired degree of temper is produced, and stopping the operation at that moment by suddenly chilling it in water. The temperatures at which given degrees of temper are produced have been carefully determined, and are indicated to the experienced workman by the color of the film of oxide which forms upon the surface of the steel, and which grows thicker and of deeper shade as the operation progresses. It must be borne in mind that a polished piece of iron or soft steel is colored by heating in air in precisely the same manner as a piece of hardened steel, and the color of the film of oxide is of no significance as a measure of temper unless it exists upon the surface of a piece of steel which is known to have been full hard; in which case the quality of the temper in specimens of steel of the same chemical composition is very accurately indicated by the shade of its surface color.

The approximate temperatures corresponding to the various tints are shown in the following table:

Temperature.	Color.	Temper.
430° to 450° F.	Very faint yellow to pale straw.	Lancets, razors, surgical instruments, enamel chisels.
470°	Full yellow	Excavators, very small cold-chisels.
490°	Brown	Pluggers, scissors, pen-knives.
510°	Brown with purple spots . . .	Axes, plane-irons, saws, cold-chisels, etc.
530°	Purple	Table-knives, large shears.
550°	Bright blue	Swords, watch-springs.
560°	Full blue	Fine saws, augers.
600°	Dark blue	Hand and pit saws.

It has been already stated that the amount of hardness which can be developed in steel is in direct proportion to the amount of carbon and rate of cooling from a heated condition. As specimens of steel vary greatly in their amount of carbon, the temperature to which it is necessary to heat them before chilling must be determined by experiment in order to produce the maximum of hardness. In all cases the metal should never be heated beyond the point necessary to attain this end, it being better to err upon the side of under- than over-heating, as under the latter condition its carbon is oxidized and the metal presents a blistered or scaly appearance, and is said to be *burned*; it then becomes incapable of taking a fine temper. Where small articles, such as drills, excavators, and other dental instruments, are to be hardened, they should always receive a protective coating of some material which will retard or prevent loss of carbon by oxidation during the heating process. Common soap answers admirably for this purpose. After being heated carefully to the proper temperature, which has been previously determined by experiment, the instrument is suddenly chilled by plunging it into water or some medium which will rapidly abstract its heat. Various

fluids and substances have been used for this purpose, and there is perhaps scarcely any department or process of metallurgy which has had attached to it more of mystery and superstition, nearly every workman in this branch of steel industry having some secret or mysterious method relating to the hardening medium which he uses; but as the only principle involved is that of the conductivity of the hardening medium, the question becomes quite simple. Water alone, or with the addition of small proportions of acid or salt—the first to aid in the separation of the scale of oxide, the latter to increase conductivity—is most commonly used, though in some instances where extreme hardness is desired mercury is used, which on account of its superior conductivity chills the heated metal instantly. With water the chilling process is slower, it being an inferior conductor, and when articles of considerable size in a heated state are plunged into it actual contact of the cold water is prevented for a moment by the formation of an envelope of steam, which surrounds the hot metal and protects it. This does not occur when the mercury bath is used. By hardening in a bath of oil or of resin its low specific heat causes the abstraction of heat from the steel to proceed slowly, and for some purposes the subsequent tempering operation, or *letting down*, is not required when either medium has been used for hardening.

When the steel has been rendered full hard—or glass-hard, as it is frequently termed—it will be found too brittle for ordinary uses, and its proper degree of toughness and elasticity is developed by reheating it carefully to the proper point; this constitutes *tempering*. The whole or a portion of the surface of the instrument is rendered bright by polishing with emery or corundum, after which it is carefully heated, either in a flame or fire or upon a hot metal support, until the proper temperature is indicated by the depth and character of the film of oxide upon its surface.[1] When the exact point is reached it is plunged instantly into cold water, and afterward finely polished, or, as in some instances—viz. springs, machine-drills, taps, and dies, etc.—the temper color is allowed to remain as an indication of their quality to the consumer.

In tempering small cutting instruments, such as enamel chisels and dental excavators, which have a tapering shank terminating in a fine cutting edge, it is necessary to protect the edge from over-heating while tempering the shank, the latter being let down to a blue or spring temper—a softer condition than it is desirable to impart to the former. This is accomplished by holding the cutting edge or extreme point of the instrument in contact with a cold iron or other metallic body, which by its conducting power prevents a too rapid or over-heating of the end of the instrument. A spring temper is given to many articles by anointing them with oil, generally animal oil, and heating them to the ignition-point of the latter. This is termed *blazing off*, and is a suitable method for tempering rubber-dam clamps.

When a number of small articles are to be hardened at a time, they are frequently heated in a bath of red-hot lead, which imparts to each a uniform temperature; after chilling them the hardness can be let

[1] See table, p. 901.

down by carefully reheating a number at a time on uniformly heated metal plates, or by the blazing-off process when desired.

The immense increase in value of manufactured steel over the crude metal is forcibly illustrated in the case of the balance-springs for watches, of which thirty-two hundred weigh but an ounce; these are worth when tempered about $1.25 each. This raises the value of the steel, originally less than four cents per pound, to about $6500.

Steel may be distinguished from wrought iron by its strength, the character of its fractured surface, which is finely granular, and by touching it with a drop of nitric acid, which develops a dark stain from the separation of carbon. The acid test, however, does not differ in this respect from the same test applied to cast iron. It may be distinguished from the latter by its superior toughness and hardness and the finer character of the granular structure of its fractured surface.

Articles of iron and steel are generally united by means of brazier's solder, for the formulas of which see section on Copper.

Mercury.

Symbol, Hg. Atomic weight, 200.

Mercury has been known from the earliest times, its occurrence in the metallic condition having no doubt led to its early discovery. The ancients applied the term *argentum vivum* to native mercury, from which arose the common name quicksilver by which the metal is ordinarily known. Mercury is found native disseminated through the vein-stone in mines of this metal, where it collects in globules in the crevices and depressions. It is also found in combination with silver as a native amalgam, and in combination with chlorine as native calomel under the name of horn quicksilver. Its most important ore, which constitutes the principal source of its supply, is its sulphide, or cinnabar, HgS, which when pure contains 86.22 per cent. of mercury.

Occurrence.—The principal sources from which cinnabar is obtained are Idria in Austria, Almaden in Spain, China, Borneo, Australia, and California.[1] The oldest mines are those of Almaden in Spain: the Greeks imported cinnabar from them, and in the time of Pliny 100,000 pounds annually were sent thence to Rome. The mines of Idria, which are under the control of the Austrian Government, were discovered in 1497. The largest amount of mercury is now furnished by California, and the product is of remarkable purity.

Extraction.—Two general methods are in use for obtaining mercury from its ore. The first consists in simply roasting the ore, with access of air, whereby the sulphur is converted into sulphurous anhydride and metallic mercury liberated in the form of vapor, which is condensed in suitable receivers of earthenware or in chambers of firebrick. The other process consists in mixing the sulphide with a certain proportion of lime or oxide of iron and distilling the mixture, in which case the sulphur combines with the flux to form calcium or iron sulphide as the case may be, a portion of the sulphide of calcium or iron being oxidized to sulphate by the oxygen of the flux. The mercurial

[1] Mexico, Chili, Hungary, Bohemia, Japan, and Sweden also furnish cinnabar.

vapors are condensed in receivers as before. The metal comes into commerce in wrought-iron bottles which hold from seventy-five to ninety pounds of metal each.

Commercial mercury is never quite pure. It is more or less contaminated with lead, tin, zinc, and bismuth; a portion of these are contained in the metal as it is made, but in passing from the hands of one dealer to another base metals are frequently added by unscrupulous persons to increase their profit, as a considerable amount of such adulteration can take place without interfering with the fluidity of the mercury. The presence of foreign metals is easily detected by allowing a globule of the suspected sample to roll over the surface of a clean glass plate or sheet of white paper, when, if the metal contains even a small percentage of base adulteration, it will "tail" or leave a streak of dross in its track, which does not occur when the mercury is pure.

Several methods are used for the purification of commercial mercury. Repeated distillation is frequently resorted to by the refiner, one of the iron bottles in which it is imported being used as a retort; but as during the process of ebullition the metal is liable to violent concussions, it is impossible to prevent a portion of the impure mercury from passing over into the receiver. A much better process, and one that is entirely manageable, applying better to small quantities, consists in pouring the metal into a wide porcelain or glass dish, such as a photographic tray, so that it may form a thin layer, and covering its surface with dilute nitric acid (sp. gr. 1.15). The acid is allowed to remain in contact with the metal for a day or two, being frequently stirred from time to time until the mercury no longer *tails* upon a glass plate. The action may be hastened by heating the bath to about 120° F. Lead, zinc, and bismuth, together with a portion of the mercury, are dissolved in the form of nitrates; the purified mercury is freed from these by washing, and afterward dried. Mechanical impurities are easily and completely removed by passing the metal through a heavy paper cone supported in a glass funnel, the paper cone being perforated at its apex by one or more small pinholes.

Chemically pure mercury may be prepared by decomposing the mercuric oxide by heat and washing the condensed metal with dilute nitric acid, or by distilling mercuric chloride with clean iron filings. It is of course essential that the purity of the mercuric oxide or chloride be assured, as otherwise the product will be likely to be contaminated.

Only chemically pure mercury should be employed in the preparation of dental amalgams, and where it cannot be readily obtained from a reliable dealer, one of the means before given should be resorted to for its purification. Treatment with dilute nitric acid yields a product sufficiently pure for this purpose. A number of other methods have been employed for the purification of mercury, but those above cited yield satisfactory results.

Properties.—Mercury is the only metal which is fluid at ordinary temperatures. It becomes solid at −39° C. Its fusing-point, accurately determined, is −38.8° C.[1] In the solidified condition it is malleable and ductile, is silver-white in color, and possesses a strong metallic

[1] *Éléments de Physique*, Ganot.

lustre. It may be obtained in a crystalline condition by cooling in a platinum crucible till partly solidified, and pouring out the portion still remaining fluid, when a brilliant mass of regular octahedral crystals remains.

Mercury is readily distinguished from all other metals by its liquidity, which it maintains at all ordinary temperatures, though in the polar latitudes it is frequently solidified. It does not lose its lustre when exposed to the air at ordinary temperatures, but if heated for some time to a temperature near its boiling-point, it is slowly oxidized to mercuric oxide. At zero Centigrade its specific gravity is 13.59. It boils at 360° C., and is converted into vapor which is highly poisonous. It evaporates slowly at temperatures below its boiling-point, which is easily demonstrated by suspending a sheet of gold-foil in a jar slightly above the surface of mercury contained in it; in a short time the lower portion of the gold-foil will be whitened by condensation of the mercurial vapor upon it. The stratum of vapor, however, does not extend much over an inch above the surface of the mercury, so that, if the strip of foil is several inches long, the upper portions of it remain unaffected. Its volatility is greatly increased by heat.

The alloys of mercury are termed amalgams. It unites more or less readily with all the metals excepting iron and platinum; the latter metal can only be amalgamated in the spongy condition. The greater number of amalgams are probably, fundamentally, chemical compounds, but in most instances with one or the other constituent in excess. This is indicated in general by their tendency to crystallize in definite forms, and in many instances by the energy of the act of combination. The amalgam of sodium furnishes a striking example of this. When pieces of sodium are thrown upon the surface of warmed mercury, union takes place with incandescence and the evolution of an amount of heat sufficient to volatilize portions of the metals. Union of potassium with mercury is attended with even greater violence. If the proportion of these metals is above 3 per cent. of the amalgam, the resulting alloy is solid and crystalline; below 3 per cent. the amalgam is fluid.

Sodium and potassium amalgam may be obtained in beautiful needle-like crystals by fusing the solid amalgam and then slowly cooling it, arresting the process before the solidification is complete, and pouring off the liquid portion. The solid amalgam of sodium, containing 1 part sodium to 30 parts mercury, is cast into ingots and employed in the amalgamating mills for gold and silver ores, where it facilitates amalgamation and prevents *flouring*.

Rubbed or agitated with chalk, sugar of milk, confection of roses, lard, suet, etc., mercury breaks up into minute globules which are not visible to the naked eye, and a variety of such preparations are used in medicine under the names of hydrargyrum cum creta, massa hydrargyri, unguentum hydrargyri, etc. Their therapeutic action is probably due not to the large quantity of metallic mercury in them, but to the small quantities of black and red oxide which occur in them through the action of the oxygen of the air upon the finely-divided metal. The proportion of oxide or oxides varies according to the age of the specimen (Attfield).

Mercury is not acted upon by hydrochloric acid nor by cold sulphuric acid; heated with the latter, it is converted into sulphate, with evolution of sulphurous anhydride. Nitric acid readily attacks and dissolves it by conversion into mercuric nitrate when the acid is used in excess, or to mercurous nitrate when the metal preponderates. Sulphur, chlorine, bromine, and iodine combine with it directly to form binary compounds.

Mercury forms two classes of compounds with other elements and radicals: those in which the latter are in the greater proportion are termed mercuric compounds, and those in which they are in lesser amount are termed mercurous compounds. The mercurous and mercuric compounds of a given element or radical are often widely different in their properties. With oxygen, mercury forms mercurous oxide, Hg_2O, a black powder unstable and poisonous, which even under the influence of light breaks up into mercuric oxide, HgO, and metallic mercury. Mercuric oxide, HgO, is a poisonous red crystalline powder, specific gravity 11.2, which is stable until heated to nearly 400° C., when it gives up its oxygen and leaves metallic mercury. With chlorine it forms mercuric chloride, $HgCl_2$, commonly called corrosive sublimate, an intensely poisonous compound, and mercurous chloride, HgCl, or calomel.

Sulphur unites with mercury to form mercurous sulphide. Hg_2S, a black powder which when gently warmed breaks up into mercuric sulphide, HgS, and metallic mercury. Mercuric sulphide, HgS, is a brilliant red crystalline mass or powder called vermilion, or, when found native, cinnabar. When pure it is of a brilliant red color and has extensive applications as a pigment: for this purpose it possesses special advantages by reason of its unalterability and resistance to chemical action. Exposure to the air at ordinary temperatures, even in the presence of moisture, produces no change in its composition. It may be completely sublimed without decomposition, and is totally insoluble in water, alcohol, and dilute nitric, concentrated hydrochloric, or sulphuric acid. It is not acted upon by boiling liquor potassa, sulphide of ammonium, cyanide of potassium, or sulphite of soda. It is slightly soluble in concentrated hot nitric acid, but readily and completely soluble in solution of potassium sulphide in the presence of free alkali, and soluble also in solution of sodium sulphide. Aqua regia decomposes it, converting it into mercuric chloride (corrosive sublimate), which is readily soluble. Exposure to a temperature of 600° F. effects its decomposition into mercury and sulphurous anhydride.

Several methods are used for its preparation. Chinese vermilion was at one time considered the most desirable in quality, but the market now affords products superior to it in brilliancy and fineness. Much depends upon the purity of the materials employed and the care used in conducting the process through its various stages.

By the dry method vermilion is obtained by intimately mixing in a mortar 540 parts of mercury with 75 parts of sulphur until all trace of the metal disappears and a black powder remains, which is gently heated until combination, which takes place with considerable energy, is complete. The black mass is then sublimed in a suitable vessel of glass or earthenware, and the resulting vermilion reduced to a fine powder by levigation.

Vermilion is obtained in the wet way by digesting mercuric chloramide (white precipitate), the compound produced upon the addition of liquor ammonia to a solution of mercuric chloride, with sulphide of ammonia holding sulphur in solution. In a few hours the mass assumes a brilliant red color by conversion into vermilion, which is collected on a filter, washed, and dried. Or the black amorphous mercuric sulphide, which is obtained by the addition of hydrogen sulphide to the solution of a mercuric salt, may be converted into vermilion by heating for some time with a solution of potassium or ammonium sulphide to a temperature of 50° C.

The latter process is modified somewhat on a commercial scale by grinding mercury with sulphur in excess to form Æthiops mineral, which consists of sulphide of mercury with an excess of sulphur, and digesting the mixture with liquor potassa, whereby potassium sulphide is formed, which acts upon the black mercuric sulphide, converting it into the red modification or vermilion, in both instances the change being due to the action of potassium sulphide upon the black variety of mercuric sulphide.

The vermilion of commerce is frequently adulterated with ferric oxide, realgar (As_2S_2), brickdust, and red lead or the basic chromate of lead. Ordinary adulterations may be detected by subliming a portion of the suspected sample, when the non-volatile substances used for adulteration will remain behind. Red lead is readily detected by its solubility in nitric acid, from solution in which it may be recognized by the proper reagents.

Vermilion is the pigment used in giving the red color to vulcanizable rubbers used in the construction of artificial dentures of red vulcanite, into the composition of which it enters in some cases to the amount of one-third of the entire weight of the compound. In view of the poisonous character of the mercurial salts in general, and the prevalence of the condition of chronic inflammation of the tissues so frequently observed in mouths fitted with dentures on the red vulcanite base, the mercuric sulphide has been looked upon as the exciting cause of what is ordinarily known as "rubber sore mouth." While it is not impossible that conditions might occasionally exist under which the mercurial compound might suffer decomposition to a sufficient extent to produce an irritating effect upon the mucous membrane in individuals whose susceptibility to mercury amounted to an idiosyncrasy, the occurrence of precisely similar conditions of oral inflammation under dentures of metal and of black vulcanite furnish conclusive evidence that vermilion alone is not accountable for rubber sore mouth, and it is probable that it seldom if ever is a factor in its production. (See article on Hygienic Relations of Artificial Dentures, p. 1018, Vol. II.)

Detection.—The addition of a small quantity of sulphide of ammonium or hydrosulphuric acid to solutions of mercuric salts causes, after shaking, a perfectly white precipitate. Addition of a somewhat larger quantity of these reagents causes the precipitate to acquire a yellow, orange, or brownish-red color according to the proportion added. An excess of the precipitant produces a purely black precipitate of mercuric sulphide. This progressive variation of color from white to black,

which depends upon the proportion of hydrosulphuric acid or sulphide of ammonium added, distinguishes the oxide of mercury from all other substances.[1]

Caustic soda or potassa yields a yellow precipitate of mercuric oxide in solutions of mercuric salts. Potassium chromate gives a red precipitate of mercuric chromate in mercuric salt solutions. Potassium iodide under similar conditions yields a precipitate which is at first yellow, but rapidly changes to a bright scarlet mercuric iodide. Stannous chloride in excess precipitates the metal, which may be collected in globules. Solution of ammonic hydrate produces in solutions of mercuric salts a white precipitate of mercuric chloramide (NH_2HgCl), known in pharmacy as "white precipitate."

One of the simplest tests for mercury in solution is a piece of bright copper-foil, which in the presence of a small quantity of free hydrochloric acid becomes coated with a silver-white layer of copper amalgam (Reinsch's test).

All salts of mercury are volatile. When heated in a glass tube with sodium carbonate, globules of metallic mercury distil off from all its salts, when the metal may be easily recognized by its physical properties.

Copper.

Symbol, Cu. Atomic weight, 63.4.

Copper exists in considerable abundance in nature both in the metallic condition and in combination with other substances, notably sulphur and oxygen. It has been known from the earliest ages; the tools found in old Egyptian quarries were formed of hardened copper. Its alloy with tin was used for the manufacture of shields, helmets, and swords by the ancients at a period greatly antedating the use of iron for such purposes. It was the material of which the arms of Homer's heroes were manufactured. The brass of the ancients was not the compound to which the name is at present applied, but a combination of copper and tin, or bronze, and the era in which it was used previous to the use of iron is known in archæology as the Bronze Age.

The word "copper" is derived from the Latin *cuprum*, which latter comes from Cyprus—or Kupros, as spelled by the Greeks—an island sacred to Venus, where it was extensively mined in ancient times. The alchemists applied the title of Venus to the metal, and the symbol of that planet was used to designate it.

Copper ores are found largely distributed both in America and in Europe. In the Lake Superior region it is found native in large masses, some of them weighing several tons. It is found also as native metallic copper in Virginia, the south-western portions of the United States, and Mexico, Chili, Cornwall, and many other parts of the world. Its chief ore is its sulphide, called copper pyrites, in which it is associated with sulphide of iron, which when pure contains about 35 per cent. of copper. Copper glance is another very important ore

[1] Fresenius, *Manual of Qualitative Analysis.*

of copper, which is found in Cornwall, the United States, and many other localities. It is when pure a definite compound of copper and sulphur, having the formula Cu_2S, crystallizing in the rhombic system. Red copper ore, cuprite, is found in Cornwall and has the formula Cu_2O. Black or cupric oxide, CuO, occurs as an ore of copper in Chili under the name of melaconite. The blue and green carbonates of copper, azurite and malachite, are found in Siberia, Australia, and Africa. The beautifully-veined green malachite is much used in the production of ornamental objects, for which purpose it is highly prized.

Extraction.—The methods used for the reduction of copper from its ores vary for the kind of ore under treatment. The oxides and carbonates are reduced by ignition with charcoal, with the addition of a little siliceous flux to form a fusible slag with any oxide of iron which is present in the ore, the metal being reduced through parting with its oxygen to the carbon, with which it combines to form carbonic oxide.

The sulphides, copper pyrites, copper glance, etc. are first roasted, by which sulphur is expelled from all the iron pyrites present, leaving it in the condition of oxide; at the same time arsenic is volatilized, and nearly pure sulphide of copper results, together with some oxide of copper and all the oxide of iron produced by the roasting of the iron sulphide. The next step in the process is for the removal of the iron, which is accomplished by completely fusing the roasted ore at a high temperature with silica, which forms a fusible silicate of iron. This process of roasting and subsequent fusion is repeated until a nearly pure copper sulphide is obtained, which is roasted, with free access of air, until a considerable proportion of the sulphide is converted into copper oxide, which upon fusion acts upon the sulphide of copper to produce metallic copper and sulphurous anhydride; thus:

$$Cu_2S + (CuO)_2 = SO_2 + Cu_4.$$

Refining of the reduced metal is accomplished by keeping it melted for a number of hours in contact with the air. The readily-oxidizable metals and some of the copper pass into the slag as oxides, while a considerable amount of cuprous oxide dissolves in the molten copper. This dissolved oxide of copper is reduced to the metallic state, and the metal rendered tough and fibrous by the "*poling*" process, which consists in stirring the melted metal with a pole or stick of green wood. If the process of poling be too long continued, the copper becomes hard and brittle again, and is said to be "over-poled." Copper which has been over-poled may have its tough, fibrous character restored or reduced to "tough pitch" by allowing air to act for a short time upon the surface of the melted metal.

Properties.—Copper is a lustrous metal of a deep salmon-red color, and is susceptible of a high polish. Its specific gravity is 8.95. It is somewhat softer than iron, and when pure may be readily cut with a knife. It is exceedingly malleable and ductile, which, with its toughness and tenacity, give it its chief value in the arts. It may be beaten or rolled into thin leaves or drawn into fine wire. Its tenacity is inferior to that of iron, but greater than that of gold, silver, or platinum. A copper wire hard drawn, having a sectional area of a square millimeter,

sustained a weight of 90.20 pounds at the moment of rupture. The same wire annealed broke under a weight of 69.52 pounds.[1]

Its conducting power for electricity is but slightly inferior to that of silver, and for heat it is only surpassed by silver and gold. It fuses at about 2000° F., and may be volatilized at higher temperatures. While in the molten condition it absorbs oxygen in the same manner that silver does under similar circumstances, so that castings made from it are always porous unless the molten metal is protected from contact with the air by a layer of charcoal or common salt. It is readily soluble in nitric acid, but slowly acted upon by hydrochloric acid. By the aid of heat it may be dissolved in concentrated sulphuric acid.

Pure metallic copper may be obtained by reducing its chemically pure oxide by igniting it in a current of hydrogen gas, or by decomposing one of its salts by metallic zinc or iron or by the galvanic current.

Copper forms two compounds with chlorine—cuprous and cupric chloride, $CuCl_2$ and Cu_2Cl_2, respectively. Cupric nitrate, $Cu(NO_3)_2$, is produced when copper is acted upon by nitric acid. Its most important compound is its sulphate, commonly called blue vitriol, $CuSO_4$, which is obtained by dissolving the oxide carbonate or hydrate of copper in sulphuric acid, or by roasting the sulphide. It crystallizes in combination with 5 molecules of water in triclinic prisms of a fine blue color. Cupric sulphate is largely used in the construction of batteries for use upon telegraph lines.

Alloys.—Under suitable conditions mercury unites with copper to form an amalgam which has been extensively used as a filling material under the name of Sullivan's cement or amalgam, the properties of which and its method of preparation have already been described in the section upon Amalgams. (See p. 807; also the experiments of Dr. W. D. Miller, Vol. I. p. 810.)

The alloys of copper have a wider range of application and usefulness than the pure metal. Its alloys with tin are much tougher, harder, and more elastic than copper itself. It is to the alloys of copper with tin in general that the term "bronze" is applied, copper and tin forming the base, though in many of the bronzes, notably the Chinese and Japanese statuary and ornamental bronzes, several other metals enter into the alloy to form a very complex mixture.

The colors of bronze alloys all tend toward the red-copper color, owing to the preponderance of that element in their composition. The red color of the copper is not fully masked until the proportion of tin reaches about 30 per cent. of the mixture, at which point the alloy assumes a grayish-white appearance. 15 per cent. of tin in the alloy greatly impairs the color of copper. Alloyed with 50 per cent. of tin, the mixture is quite white.

The physical properties of copper are greatly and rapidly modified by the addition of tin in increasing proportions. Fusibility is increased, as well as hardness, while malleability and ductility proportionately diminish. The tough, tenacious, and fibrous character of copper when worked with tools is modified when alloyed with tin. Thus, copper

[1] Ganot, *Éléments de Physique.*

alloys containing about 8 to 9 per cent. of tin cut easily and smoothly, while with 15 to 16 per cent. of tin they assume the maximum of hardness without becoming brittle or crystalline. After this point they yield to the file by crumbling in minute fragments rather than by cutting in fine shreds, as with a softer and fibrous alloy, until the proportion of tin preponderates over the amount of copper, when the alloys again become soft, malleable, and ductile as the proportion of copper decreases to a minimum. Copper and tin tend to form an alloy of definite chemical composition in the proportion of about 2 parts of copper to 1 part of tin, all other alloys of these metals being probably solutions of this definite compound in the metal which is present in the alloy in excess, as during the cooling of copper-tin alloys the mixture tends to separate into two parts, one containing more copper, which, being denser, settles toward the bottom of the casting and solidifies first, and the other, richer in tin, more fusible, which solidifies last.

The more important copper-tin alloys are gun-metal, composed of $90\frac{1}{2}$ parts copper and $9\frac{1}{2}$ parts tin; bell-metal, 4 parts copper and 1 part tin, the proportions being varied somewhat according to the size of the bell; speculum-metal, made on a basis of 2 parts copper and 1 part tin, with the addition of a small amount of arsenic or zinc to improve its color and reflecting qualities.

The bronze weapons and tools of the ancients contained from 8 to 15 per cent. of tin, sometimes with the addition of a small amount of zinc. The mode of tempering bronze weapons was the reverse of that employed for steel, the bronze being rendered soft and somewhat malleable when heated and quenched in water, but being again hardened when heated and cooled slowly.

Copper and zinc unite readily in all proportions, though there is evidence which indicates that in certain proportions they unite to form a definite chemical compound. The copper-zinc alloys are grouped under the term "brass." The color of the alloy depends, of course, upon the relative proportions of its ingredients. Those alloys which contain over 80 per cent. of copper incline to a reddish-yellow tint, the color becoming decidedly yellow or "brassy" as the amount of copper falls below 80 per cent. When the proportion of copper is less than 35 per cent., the yellow color disappears and the alloy approaches more nearly the color of zinc. (For the physical properties of the copper-zinc alloys see the tabulated results of Prof. R. H. Thurston's research, p. 799.)

The most malleable of the brasses is Dutch metal, composed of copper 11 parts, zinc 2 parts; it can be rolled out into thin sheets and afterward be beaten into leaves of extreme tenuity, and is used in this form for decorative purposes under the name of *Dutch leaf-gold*, or, reduced to powder by levigation with a small quantity of oil or honey, it is sold as *bronze powder*. Various shades of bronze powder are made by varying the amount of copper in the alloy.

Pinchbeck, used for cheap imitation jewelry, is composed of 3 parts copper and 1 part zinc. Prince's metal contains 6 parts copper and 1 part tin. Mosaic gold[1] contains about equal weights of the two metals.

[1] This term is also applied sometimes to sulphide of tin.

Muntz's malleable brass or yellow sheathing differs from common brass in being malleable while hot; it is composed of 3 parts copper and 2 parts zinc. Aich metal or Gedge's metal and sterro-metal are brasses which contain a small amount of iron; they are remarkable for their great strength.

The copper coinage of the United States consists of copper, 95 per cent.; tin, 3 per cent.; zinc, 2 per cent.; that of England, 95 per cent. of copper, 4 per cent. of tin, 1 per cent. of zinc.

With nickel, copper forms a tough white alloy which is used in this country for small coinage: the three- and five-cent pieces are composed of copper, 75 per cent.; nickel, 25 per cent. Copper and nickel, with the addition of zinc, form the alloy known as argentan or German silver, the proportions of which vary greatly with the use for which it is intended. The commonest made contains about 8 parts copper, 2 nickel, and 3.5 zinc. With a lower amount of zinc the alloy would tarnish rapidly. With the same proportions of copper and zinc as in the foregoing, and 3 parts nickel instead of 2 parts, a high-class German silver is obtained, corresponding in color to silver a little below standard. The proportion of nickel in this alloy cannot, it is stated, be increased beyond 6 parts without injuring its mechanical qualities.

Gold and silver have their toughness and hardness increased by alloying with small proportions of copper, while malleability is but slightly interfered with; hence copper enters into all the alloys of these metals for coinage, jewelry, plate, etc. Both the gold and silver coinage of this country and France contains 10 per cent. of copper. England employs a somewhat arbitrary standard of 925 parts silver to 75 of copper for her silver coinage, and 916.6 parts gold and 83.3 parts copper for her gold coinage.

The alloy of copper and platinum has already been alluded to. (See section on Platinum.) Copper forms a similar alloy with palladium, but lighter in weight and color.

With aluminum, copper forms a number of important and remarkable alloys called aluminum bronze: they have a color nearly approaching that of gold, are fine-grained and not easily tarnished, and are possessed of great toughness and tensile strength, surpassing in this latter quality many specimens of wrought iron. (See Aluminum.)

With lead, copper forms an inferior brittle alloy known as "pot-" or "cock-" metal: the two metals do not unite readily, as they possess little or no affinity for each other.

Copper is a valuable constituent in alloys used for dental amalgams in positions where discoloration of the filling and surrounding tooth-structure is not a serious objection to its employment. It enters into the composition of a number of dental alloys in general use to the amount of from 2 to 10 per cent. Mr. Fletcher claims that it is inferior to platinum as a constituent of these alloys, but experience seems to show that with regard to the preservative qualities of such alloys it is fully equal if not superior to the corresponding platinum combinations, though the latter undoubtedly retain their color better.

Copper surfaces are united by various kinds of solder, according to the use to which the article is to be applied. It may be soft soldered

by the ordinary tinman's solder, but a harder and more infusible alloy is generally used, known as spelter or brazier's solder, or the ordinary silver solder may be used when the expense is not an objection. The composition of three grades of excellent brazier's solder found in commerce is as follows:

	Copper, parts.	Zinc, parts.	Tin, parts.	Lead, parts.
A, golden yellow . .	53.50	43.33	2.12	
B, medium light . .	43.75	50.58	3.75	1.
C, white	57.50	27.90	14.90	trace.

Aluminum bronze may be soldered to itself or to gold by the following alloy: copper, 8 parts; aluminum, 12 parts; zinc, 80 parts—melted together in the order named. For larger articles, copper, 4 parts; aluminum, 6 parts; zinc, 90 parts. To solder iron and steel, copper or brass may be used, or for small articles prepare a solder by granulating a mixture of 8 parts brass with 1 part zinc. Mix this with borax cream and spread it over the articles to be joined, and fuse the solder with the blowpipe or a charcoal fire. For very small articles a solder prepared by melting together 6 parts brass, 1 part zinc, and 1 part tin is used. The solder is beaten into thin plates and cut into pieces, which are applied with borax to the surfaces of the articles to be soldered.

(For the composition of various gold and silver solders see sections on Gold and Silver.)

Detection.—Copper, its alloys, and other compounds when heated in the inner or reducing flame of the blowpipe or gas flame impart an emerald-green tint to the outer or oxidizing flame. Moistening the specimen with hydrochloric acid considerably heightens the delicacy of the reaction. Salts of copper, when mixed with sodium carbonate and heated on charcoal with the reducing flame of the blowpipe, produce metallic copper in globules. Salts of copper when heated with borax in the outer blowpipe flame yield a bead which is green while hot and blue when cold.

When a solution containing copper is acidulated with hydrochloric acid and a drop is placed upon the bright surface of a piece of platinum-foil, metallic copper is instantly reduced upon it by touching the fluid and foil with a piece of metallic zinc, the copper being easily recognized by its color.

Hydrogen sulphide, H_2S, and ammonium sulphide, NH_4HS, produce in copper solutions a brownish-black precipitate of cupric sulphide, which is slightly soluble in ammonium sulphide and entirely soluble in boiling nitric acid. The precipitation is prevented by the presence of potassium cyanide. Sodium and potassium hydrates produce a light-blue precipitate of cupric hydrate, $Cu(OH)_2$, insoluble in excess, and converted by boiling into black cupric oxyhydrate, $(CuO)_2Cu(OH)_2$. In the presence of non-volatile organic acids this precipitation does not take place, but a blue coloration results.

Ammonium hydrate in small quantity forms a greenish-blue precipitate readily soluble in excess, forming tetra-ammonio-cupric sulphate,

$(NH_3)_4CuSo_4,H_2O$. Potassium ferrocyanide yields a reddish-brown precipitate of cupric ferrocyanide, $Cu_2Fe(CN)_6$, which is insoluble in dilute acids, but is decomposed by potassa or ammonia. In very highly-diluted solutions the reagent produces only a reddish coloration of the fluid.

Metallic iron when brought in contact with concentrated copper solutions is almost immediately coated with a film of metallic copper. The action is accelerated by the presence of a free acid.

Determination.—Copper may be estimated in the form of oxide, sulphide, or as metallic copper. The determination as oxide is applicable to all alloys of copper and such of its compounds as are decomposable by nitric acid and in the absence of non-volatile organic acids. The copper solution is heated to near its boiling-point, and solution of potassa or soda added as long as any precipitate falls. The precipitate is allowed to subside, and is washed with boiling water several times by decantation. It is then collected upon a filter and thoroughly washed with hot water, then dried, and ignited in a platinum crucible, carefully guarding against the action of reducing gases during the process, after which it is allowed to cool in a desiccator and weighed. The ignited oxide contains 79.85 per cent. of metallic copper.

In all solutions which are free from other metals which are precipitable by zinc the copper may be estimated as metallic copper. For this purpose the copper solution is acidulated with hydrochloric acid and transferred to a weighed platinum dish. A piece of pure zinc is added; a brisk evolution of hydrogen takes place, accompanied by a deposition of metallic copper upon the sides and bottom of the dish. The action is continued until the solution is completely decolorized and the zinc is dissolved. The precipitated copper is then washed repeatedly with hot water to remove all traces of hydrochloric acid and zinc chloride, and lastly with alcohol, after which it is dried in a water-bath, cooled, and weighed. The gain in weight which the dish has undergone represents the weight of metallic copper. The same result is obtained without zinc by using a weak galvanic current and making the dish the negative pole, while a strip of platinum-foil is used as an anode. This method is quite accurate.

Estimation as sulphide is accomplished by passing hydrogen sulphide into the nearly neutral copper solution until precipitation is complete, and washing the precipitate with water containing hydrogen sulphide to prevent oxidation, then collecting the cupric sulphide on a filter and drying, after which it may be transferred to a porcelain crucible and strongly ignited with the addition of some powdered sulphur in a stream of hydrogen until the weight is constant. The sulphide thus obtained contains the same amount of copper as the cupric oxide—viz. 79.85 per cent.

(For the determination of copper in dental amalgam alloys see section on Amalgams.)

Tin.

Symbol, Sn (Stannum). Atomic weight, 118.

Tin has been known from the earliest ages. It is spoken of by Moses (Num. xxxi. 22); Homer also mentions it in the *Iliad;* Herodotus refers to the British Islands as the tin islands. Much of the brass of the ancients was a copper and tin bronze, the tin being obtained from Cornwall. The principal deposits of tin ore are at Cornwall, England, and Banca and Malacca, India. It has also been found in New Hampshire, California, and Virginia in this country. The principal ore is the native stannic oxide, constituting the mineral called cassiterite. It occurs in veins running through ancient rocks—*vein or mine tin;* and also in alluvial deposits in water-courses from the disintegration of these rocks—*stream tin.* It is rarely if ever found in the metallic state.

To obtain the metal, the ore is stamped and washed to remove the earthy impurities associated with it, after which it is roasted to remove arsenic and sulphur; by which operation the greater part of any copper which is present as copper pyrites is converted into cupric sulphate, the latter change being completed by allowing the roasted ore to remain in contact with the air in a moist state for some days. The roasted ore is again washed in a wooden tank to remove all the sulphate of copper and the oxide of iron which is usually present from the roasting of iron pyrites. The tin ore thus prepared, and which contains about 60 per cent. of tin, is now ready for smelting. It is mixed with from 12 to 20 per cent. of ground anthracite coal and heated in a reverberatory furnace. A little lime is added to form a fusible glass or slag with any silica which may be present. The temperature is carefully and gradually raised for about five hours, by which time it should have reached its maximum. The mass is now thoroughly stirred, and the heat continued for about an hour longer, when the reduction is completed. The furnace is then tapped and the metal run off into moulds.

The ingots as obtained from the smelting furnace contain various impurities—viz. copper, iron, arsenic, sulphur, and tungsten. To remove these it is subjected to the further refining processes of *liquation* and *boiling.* The first consists in moderately heating the ingots on the hearth of a reverberatory furnace, when the greater portion of the tin liquefies, leaving behind the impurities, which are more infusible, and the metal flows out of the furnace into a refining basin. In this receptacle, which is kept heated by a separate fire, the metal is subjected to the boiling operation, which consists in plunging stakes of wet wood beneath its surface: these are held in position by a suitable lever above the refining basin. The heat of the melted metal causes a brisk evolution of steam from the moist wood, which agitates it and exposes a large surface to the action of the air, whereby the impurities are oxidized and removed from the surface in the form of dross. When the boiling operation, which occupies two or three hours, is finished, the metal is allowed to remain quiet for a length of time sufficient to let such impurities as still remain settle to the bottom of the basin, leaving the purer metal on top. This is ladled off and cast into ingots, and in commerce is known as *refined tin;* that which occupies the middle por-

tion of the basin is sold as *common tin;* while that which rests upon the bottom is unfit for commercial uses, and is again subjected to refining processes. Grain tin is a very pure form of commercial tin which comes in the shape of irregular fragments produced by allowing the heated ingots to fall from a height. Block tin comes in the form of ingots and is less pure. Straits tin is the purest commercial form, and is imported from the island of Banca.

Pure tin is a soft metal of a brilliant white color and extremely malleable; it may be beaten into leaves one-fortieth of a millimeter thick. At the boiling-point of water it is sufficiently ductile to allow of drawing into wire. It is, however, deficient in tenacity. It is a good conductor of heat and electricity. It has a peculiar and characteristic odor. A cast bar of tin in being bent emits a peculiar grating or crackling noise, produced by the forcible disarrangement and friction of its crystalline particles. This sound is known as the *cry of tin,* and serves as a ready means for distinguishing it from similar metals.

Tin melts at 228° C.[1] (439.2° F.). It becomes brittle at 200° C., and can then be readily fractured. At a white heat it may be distilled. Heated in the air to a sufficiently high temperature, it burns with an intense white light, forming tin dioxide, a yellowish-white powder, the well-known polishing putty. It does not readily oxidize in the air at ordinary temperatures, nor is it easily acted upon by weak acids; hence its use as a coating for culinary vessels, etc. Tin possesses a distinctly crystalline structure, cast masses being generally made up of aggregations of small quadratic crystals. The beautiful arborescent effect produced upon the surface of tinned iron plate, known as *moire métallique,* is obtained by heating the plate to the fusing-point of the tin and suddenly cooling it, after which the film of oxide upon the surface is removed by wiping it with a bunch of tow wet with a dilute solution of hydrochloric acid, which exposes the beautiful crystalline arrangement below. Hot hydrochloric acid acts upon tin with considerable energy, converting it into stannous chloride, the action being attended with the evolution of hydrogen—

$$Sn + 2HCl = SnCl_2 + 2H.$$

Anhydrous nitric acid does not act upon tin, but by somewhat dilute nitric acid it is oxidized to metastannic acid, H_2SnO_3.

Nitro-hydrochloric acid acts energetically upon tin, converting it into stannic chloride, $SnCl_4$. Boiling solutions of the caustic alkalies dissolve tin, forming stannates with evolution of hydrogen—

$$Sn + 2KOH + H_2O = SnO_3K_2 + 2H_2.$$

Sulphuric acid converts it into stannic sulphate.

Alloys.—Tin under suitable conditions unites readily with most metals to form alloys. Many of these are extremely useful and important. The amalgam of tin is largely used for the manufacture of mirrors. Pewter, britannia metal, soft solder, type-metal, bronze, etc. are alloys in common use, in all of which tin is an essential constituent.

[1] Bloxam gives 227.7°; Richter, 228°; Barker, 230°.

The following table will show approximately the percentage composition of a number of the alloys in common use containing tin:

	Tin.	Lead.	Copper.	Antimony.	Brass.
Pewter	75.	25.			
Britannia metal	89.90	. .	1.83	6.42	1.84
Plumber's solder (coarse)	50.	50.			
" fine solder	65.	35.			
Bronze	10 to 15	. .	85 to 90		
Bell-metal	15 to 25	. .	75 to 85		
Type-metal	5.	75.	. . .	20.	
Babbitt metal (Dr. L. P. Haskell's formula)	72.72	. .	9.09	18.18	

All of the alloys commonly used for the formation of dental amalgams contain from 40 to 60 per cent. of tin.[1]

Tin enters largely into the composition of the alloys which have been used in the cheoplastic process for constructing artificial dentures. That of Dr. G. F. Reese consists of 20 parts tin, 1 part gold, and 2 parts silver.[2]

Tin unites readily with gold, platinum, and palladium at temperatures far below the melting-points of the latter metals respectively by reason of its chemical affinity for them. That such affinity does exist may be readily demonstrated by wrapping a small quantity of precipitated platinum in a piece of tin-foil and gently heating it, when combination takes place almost with explosive violence. The superior affinity of tin for gold has been experimentally demonstrated by Dr. Matthiessen. A rod of copper and a similar rod of gold were plunged into different parts of a crucible of melted tin. The gold combined rapidly with the tin, but the copper rod, though previously tinned to ensure perfect contact, was not perceptibly affected. A gold rod superficially tinned and held in the gas flame of a Bunsen burner melted at once like a rod of pure tin, while a tinned copper rod exposed to the same temperature remained unaffected as a whole, though the tin coating easily melted. The difference in the energy of the chemical affinity of the tin for the gold and copper respectively becomes apparent in the foregoing experiments when the slight difference between the melting-points of gold and copper is taken into account.

The alloy of gold and tin is perfectly malleable when the tin does not exceed 10 per cent. It has a specific gravity greater than the mean of its constituent metals.

Platinum and tin form a brittle alloy which is comparatively fusible.

Palladium forms brittle alloys with tin.

Silver and tin, united in the proportion of 80 per cent. of the former to 20 per cent. of the latter metal, was found by Muschenbröck to produce a tough alloy with a tenacity superior to that of pure silver.

Tin unites with iron to form an alloy. This takes place in the process of manufacture of tinned iron plate. After being pickled to remove the superficial film of oxide, the iron plates are carefully dried

[1] See composition of amalgams, p. 814.

[2] "Amalgams and Alloys Chemically Considered," by J. Morgan Howe, M. D., *Transactions New York Odontological Society*, 1880.

and immersed in a cast-iron pot containing melted tin covered with a layer of melted tallow, which is kept heated to near the inflaming-point of the latter. The plates are allowed to remain in this tin bath from one and a half to two hours or longer, according to their thickness, after which the superfluous tin is allowed to drain off by placing them on an iron grating. The coating thus formed is an alloy consisting of iron and tin, which is firmly adherent. Additional tin is afterward added by which the coating is equalized.

Alloys of tin with lead are tougher and harder than either metal separately, and on this account are sometimes used for making counter-dies for swaging dental plates.

Commercial tin is frequently impure, being contaminated with small quantities of lead, iron, arsenic, antimony, bismuth, etc.

Chemically pure tin may be prepared by decomposing a solution of stannous chloride by the galvanic current. Thus obtained, the metal is in the form of fine feathery crystals. It may also be obtained perfectly pure by dissolving commercial tin in hydrochloric acid, filtering the solution, and precipitating the tin as stannic oxide by the addition of nitric acid. This, after being washed and dried, is reduced to the metallic state by fusion with sodium carbonate and powdered charcoal in a crucible.

In the form of foil, tin is used as a filling material for carious teeth. Its extreme softness practically limits its use to such cavities as are not subjected to the attrition of mastication, but these properties render it very valuable in suitable positions on account of its adaptability to the cavity-walls.

Used in connection with gold-foil in the same cavity, it is commended by several operators, it being claimed that disintegration of the tooth-structure by galvanic action at the margins of a cavity so filled is rendered impossible, from the fact that any such action is confined to the metals, which form a closed circuit, tin-foil being more electro-positive to gold than tooth-structure.

A number of preparations of tin consisting of shredded foil have been used as filling materials, but the author has not found that they possess any advantage over the plain foil, the resulting filling lacking density and solidity unless extreme care is used in their introduction.

On account of its slight affinity for sulphur, and the fineness and smoothness of its polished surface, tin-foil is largely used as a coating for plaster casts and the formation of moulds for making artificial dentures and articles of vulcanite. After the vulcanization has been completed upon a cast so coated, upon removal of the tin-foil the vulcanite will be found to bear a highly-polished surface, a counterpart of that of the tin-foil coating.

Bulky lower cases of vulcanite are sometimes loaded with tin to give them additional weight, and, by lessening the quantity and thickness of the rubber, prevent porosity of the finished plate.

Compounds of Tin.—Tin forms two compounds with oxygen—stannous oxide, SnO, and stannic oxide, SnO_2. The first is obtained by heating stannous hydrate, SnO_2H_2, in an atmosphere of carbon dioxide. It is a blackish-brown powder, which upon being heated in the air

burns and becomes stannic oxide. Tin dioxide or stannic oxide, SnO_2, is found in nature as tin-stone or cassiterite, and is the principal source of the supply of tin. It may be prepared artificially by heating metallic tin in the air, when it forms as a white amorphous powder by union of the metal with the oxygen of the air. The dioxide may also be obtained by acting upon tin with dilute nitric acid. Tin dioxide is the well-known *polishing putty* used for giving the final polish to various stones, rocks, plate glass, etc. It is infusible, and not soluble in acids or alkalies. The hydrate of this oxide exists in two allotropic modifications which are isomeric. The first, prepared by adding ammonic hydrate to a solution of tin tetrachloride, is soluble in nitric acid, hydrochloric acid, and the alkalies. The second variety, obtained as a white powder by warming tin with dilute nitric acid, is insoluble, and is commonly called metastannic acid. Both varieties have the same formula, H_2SnO_3. The sodium salt of metastannic acid is used as a mordant in dyeing.

The chlorine compounds of tin are stannous chloride, $SnCl_2$, and stannic chloride, $SnCl_4$. The first is formed when tin is acted upon by hydrochloric acid. The second is obtained by the action of chlorine upon heated tin or upon stannous chloride, or by dissolving tin in aqua regia. A mixture of these two chlorides of tin is used in the preparation of the mineral pigment purple of Cassius. (See p. 858.)

With sulphur, tin forms a brilliant yellow compound of metallic lustre, stannic sulphide, SnS_2, commonly called *mosaic gold*, which is used for bronzing.

Detection.—Tin may be detected in its compounds by fusing the compound on charcoal with sodium carbonate before the blowpipe, when a globule of metallic tin will result, which is easily recognizable by its physical characteristics.

Gold trichloride throws down from dilute solutions of stannous chloride a characteristic purple precipitate. The reaction is more marked when both chlorides of tin exist in the solution. Alkalies throw down a white precipitate of stannic or stannous hydrate, as the case may be. Hydrogen and ammonium sulphides cause a precipitate of dark-brown monosulphide of tin.

Lead.

Symbol, Pb (Plumbum). Atomic weight, 206.4.

Lead is probably never found in the metallic condition in nature, but always in combination. Its sulphide, galenite, PbS, constitutes its chief ore. Galenite is easily recognized by its dark-gray color, semi-metallic lustre, and great weight (sp. gr. 7.5). It can be easily split in the lines of its cleavage-planes into rectangular fragments, and often occurs in distinct cubical crystals of great size. Its reduction is accomplished by first roasting the ore with free access of air, by which a portion of the lead sulphide is converted into oxide and sulphate of lead; thus:

$$PbS + 3O = PbO + SO_2,$$

and

$$PbS + 4O = PbSO_4.$$

Upon ignition of these two substances in a reverberatory furnace, with the air excluded, they react with the lead sulphide, as follows:

$$2PbO + PbS = 3Pb + SO_2,$$

and

$$PbSO_4 + PbS = 2Pb + 2SO_2.$$

Metallic lead is the softest of the metals in common use. It is very malleable and ductile, which properties render it capable of being readily rolled into thin sheets or foil. It has little tenacity. A freshly-cut surface exhibits a bluish-white metallic lustre, which soon tarnishes by exposure to the air. The formation of this superficial film protects the remainder from oxidation. Its specific gravity is 11.37. It is fusible at a temperature somewhat higher than that at which tin melts, the fusing-point of lead being 617° F. (325° C.). Heated in the air, it burns to lead oxide, PbO. With exclusion of the air it can be volatilized at about a white heat.

Its chief use in the dental laboratory is for the formation of counter-dies. It was at one time used in the form of foil as a filling material for carious teeth.

Pure lead may be obtained in a beautiful arborescent form by suspending a rod of zinc in a solution of the acetate or nitrate of lead.

Alloys.—The most important alloys of lead are those with tin, with which it unites in all proportions to form combinations which are more fusible and tenacious than either metal singly. They are largely used under the name of pewter and soft solder, of which latter the proportionate amounts of each constituent vary greatly according to the use for which they are intended. Lead is also the principal ingredient in type-metal, of which it generally forms as much as 50 per cent.

Lead and mercury readily unite to form an amalgam; the combination is accompanied by a condensation of volume, owing to the formation of a definite chemical compound between the metals, which has the formula Pb_2Hg.

Lead unites with all the noble metals, but completely destroys their malleability, rendering them extremely brittle and consequently unworkable. Gold containing .002 per cent. of lead is rendered thereby unfit for coinage. The deep-yellow color of gold is rapidly impaired by union with lead. Silver alloys freely with lead, and within certain limits the silver-lead alloy is more fusible than pure lead. This fact was turned to valuable account by Pattinson in 1829 for extracting the silver from argentiferous lead. The silver-bearing lead is fused and allowed to cool slowly, when nearly pure lead crystallizes out, leaving the silver still dissolved as an alloy with a portion of the lead, which alloy remains fluid; the crystals of pure lead are ladled out. This is repeated until the lead-silver alloy becomes very rich in silver, when the latter metal is recovered by cupellation.

Gold and silver scrap and filings from the manufacture of dental plates frequently become contaminated with lead, which may be removed by cupellation or by dropping small lumps of potassium nitrate upon the surface of the metal, which has been brought to a state of fusion in a crucible. It is essential that every trace of lead be removed, as the

smallest admixture decidedly impairs the ductility and malleability of either gold or silver.

Platinum and lead, as well as palladium and lead, form hard and brittle alloys. Both platinum and palladium are freely soluble in lead at comparatively low temperatures. Compounds of lead should therefore never be heated in platinum crucibles, as an accidental reduction of the lead compound would cause the sudden loss of the vessel.

Lead is unacted upon by concentrated sulphuric, nitric, hydrochloric, or hydrofluoric acid, in consequence of which it is much used in chemical industries and manufactures. It is soluble in somewhat dilute nitric acid (sp. gr. 1.2).

Concentrated nitric acid does not act energetically upon lead, for the reason that the lead nitrate is insoluble in strong nitric acid, and this salt forms a coating upon the metal which prevents any further action.

Detection.—Compounds of lead heated on charcoal before the blowpipe flame coat the charcoal support with a film of oxide, which is a dark lemon-yellow while hot and sulphur-yellow when cold. Metallic lead imparts an azure-blue tint to the reducing area of the blowpipe flame. Many salts of lead impart an intense azure-blue tint to the outer flame when heated on a platinum wire.

Hydrochloric acid or soluble chlorides cause a white precipitate of lead chloride, which is soluble in hot water.

Potassium chromate gives a characteristic yellow precipitate of lead chromate, or *chrome-yellow*, which is soluble in potassium hydrate or strong nitric acid. Potassium iodide forms a brilliant yellow precipitate of lead iodide, soluble in boiling water.

Zinc.

Symbol, Zn. Atomic weight, 65.

An ore of zinc was known to the ancient Greeks, who used it for the production of brass. It was called by them cadmia, for Cadmus, who first taught them its use. The name "zinc" was first applied to the metal by Paracelsus in the sixteenth century. The first zinc made in Europe was during the eighteenth century, but previous to that time it was imported from China.

Under the name of calamine[1] two zinc ores are known—one a hydrous silicate, the calamine proper; the other, a carbonate, now termed smithsonite. Zinc blende, the native sulphide, or sphalerite, and red zinc, or zincite, which is a native oxide of zinc colored red by the oxides of iron and maganese, are the principal ores of zinc. It is never found in a metallic state in nature.

Sphalerite (zinc blende) and smithsonite, the native carbonate, are the most valuable ores of zinc.

In order to extract zinc from its ores, they are first stamped, washed, and roasted, by which means sulphur is removed if the ore operated upon be blende, or carbonic acid and water if smithsonite: in each case the roasted ore consists mainly of zinc oxide. The roasted ore is then

[1] A corruption of cadmia.

mixed with carbon and distilled, when the oxygen passes off in combination with carbon as carbonous oxide; metallic zinc is volatilized and condensed in the neck or outlet tube of the retort, advantage being taken of the comparative facility with which the metal is converted into vapor, since it may be distilled freely at a temperature which has been estimated at about 1900° F., a bright red heat somewhat below the melting-point of copper. The distillation is effected in retorts or muffles constructed of fireclay or earthenware.

The chief localities for the production of zinc are at Birmingham and Bristol in England, Silesia and Belgium on the Continent, and Bethlehem and Bergen Hill in this country.

Properties.—Zinc is a bluish-white crystalline metal with a specific gravity of about 7.0. It is hard and brittle at ordinary temperatures. Previous to the year 1812 it was almost exclusively used for the manufacture of brass, but at that time it was discovered that a temperature between 200° and 302° F. rendered it malleable and capable of being rolled into thin sheets. At temperatures above 302° F. it again becomes brittle. It melts at 773° F. (412° C.), and at a temperature variously estimated from 1840° to 1900° F. it boils, and is converted into vapor. Upon cooling from a state of fusion it crystallizes in rhombohedra. When strongly heated in the air it burns with a brilliant flame, producing a white oxide, ZnO. Zinc becomes coated in moist air with a thin layer of basic carbonate, and is easily acted upon by dilute acids, alkaline hydrates, and the halogens.

Zinc is used to form the positive element of all galvanic batteries, and in the form of sheets it has extensive application in the arts. It readily alloys with iron, and is used as a coating for that metal, which it protects by a galvanic action; hence iron so treated is called "galvanized iron." Its alloy with copper, termed brass, is the most important of its alloys used in the arts.

In the dental laboratory zinc is valuable as a metal to form dies for the construction of dental plates, etc. Its low fusibility and comparative hardness render it particularly suitable for this purpose.

In passing from a low to a higher temperature zinc increases in volume in a greater ratio than any of the metals in common use. The coefficient of its cubical expansion between zero and 100° Centigrade, which represents the rate of increase of its unit volume between these temperatures, has been found to be 0.000088251, or nearly three times that of cast iron. The rate of expansion of liquids being greater than that of solids, and as this rate is not constant, but increases with the temperature, the rate of increase in volume which zinc undergoes in passing from the solid to the fluid condition would be represented by a figure somewhat higher than that given above. From the fact that metal plates for entire dentures which have been swaged upon dies made of zinc generally fail to fit the plaster model accurately, it is held by some practitioners that the high rate of expansibility of zinc is an undesirable feature; but as the absolute contraction in the size of a zinc die is but slight, and as the difference in the size of a plate made upon it and that of the mouth for which it is intended is to a certain extent reduced or counteracted by the expansion which the plaster model

undergoes in setting, it is questionable whether the contraction which takes place in zinc on passing from the fluid to the solid condition is of any detriment. It is held by many, and for potent reasons, that in most cases the contraction which occurs in a zinc die is of positive benefit. A plate swaged upon a zinc die is, by reason of the contraction which the metal undergoes in passing from the fluid to the solid state, slightly smaller than the mouth it is intended to fit, thus bringing the greatest pressure to bear upon the alveolar ridge. Should the plate be made to fit upon the plaster cast, it would be a trifle larger than the mouth, as plaster expands in setting, and two expansions have taken place in taking the impression and making the cast. The pressure exerted by such a plate would be expended upon the bony arch of the hard palate. Usually, the tissues covering the alveolar ridge are thicker, and therefore more yielding, than those covering the hard palate, and a plate swaged upon a zinc die would be of positive advantage, as the slight absorption of the tissues covering the alveolar ridge which result from the increased pressure would soon bring about a perfectly uniform bearing over the entire area covered by the plate. But one class of cases arises, and their occurrence is infrequent, where the quality of expansibility of zinc is detrimental to the fit of a plate when swaged upon it —namely, where the tissues covering the bony arch of the hard palate are thick and spongy, while the alveolar ridge is hard and covered by a thin, unyielding membrane. When this set of conditions presents, it is usually in combination with a high V-shaped arch. In such cases a die of Babbitt[1] metal gives better results, though even with a zinc die the difficulty can be readily overcome and a proper adaptation secured by properly manipulating the plaster cast or impression—*i. e.* by scraping those portions of the cast which represent the soft, yielding portions, or by treating the impression in like manner at those positions which represent the hard or unyielding parts of the ridge.

Prof. Essig says[2] of the high expansibility of zinc: "I am satisfied that the property of expansibility in zinc as used in the dental laboratory constitutes one of its most valuable qualities, as it gives us the means of compensating for the yielding of the tissues and the absorption along the ridge which nearly always follow the first insertion of an artificial denture."

Zinc is particularly valuable for the production of counter-dies; being hard and unyielding, it renders the adaptation of the plate both easy and perfect. The zinc counter-die is essential in the production of plates of rigid metals or alloys, such as platinized silver or gold and the platinum-iridium alloy. When a zinc counter-die is used, the plate must be again swaged upon a new die with a lead counter, as the rigidity of both die and counter when each is made of zinc is equal, and they both yield to the same extent under the force necessary to bring the plate into adaptation. The finishing die with its lead counter-die therefore corrects an error in fit which the plate has sustained from the yielding of the die under the zinc counter.

No difficulty attends the making of a zinc counter-die if ordinary care is used. The die must be quite cold, or at least cool enough to

[1] See formula of Dr. L. P. Haskell, p. 917, *ante*. [2] *Dental Metallurgy*, Essig.

bear handling with the naked hands, and the zinc from which the counter is to be cast must not be heated beyond the point of complete fusion. It must then be poured quickly in a full, uninterrupted stream upon the die. If the metal is poured in a small stream which is irregular or broken in its continuity, ridges and wavy lines are produced upon the surface of the counter-die. Perfection of surface is attained by pouring the metal, as before stated, quickly and in a full, large stream.

Adhesion of the die and counter-die from partial fusion of the former can only take place when the casting of the latter has been performed at too high a temperature. The right moment for casting the counter can be accurately determined by allowing the fluid metal to stand until partial solidification begins to take place at the sides of the melting-ladle, at which moment the zinc should be cast without delay. It has been recommended to coat the surface of the die with whiting or to form a deposit of carbon upon it by holding it in the smoking flame of burning resin or camphor previous to casting the zinc counter-die, for the purpose of preventing adhesion of the latter. Such a precaution is, however, altogether unnecessary when care is taken to pour the zinc counter at the proper temperature.

Alloys.—As before stated, zinc readily forms alloys with iron. Union of the zinc used for making dies and counter-dies with the iron ladle used for its fusion sometimes takes place in the laboratory. This may and should be prevented by coating the inside of the ladle with whiting or kaolin, as in the course of time the zinc becomes contaminated with iron to an extent that greatly diminishes its fluidity, rendering it thick and mushy, at the same time making it much more difficult to fuse.

With copper, zinc forms a number of valuable alloys under the general name of brass. Gilding metal, much used as a base for common jewelry, pinchbeck, Manheim gold, and semilor, used for the same purpose, Muntz's metal for ship-sheathing, spelter solder, consisting of equal parts zinc and copper, are examples of copper and zinc alloys in common use. Mosaic gold, which is dark colored when cast, but upon dipping in acid assumes a beautiful golden tint, is composed of $16\frac{1}{4}$ to 17 ounces of zinc to each pound of copper. Bath metal contains from 3 to 4 ounces of zinc to the pound of copper. The ordinary range of good yellow brass, that files well and can be readily worked in a lathe, is from $4\frac{1}{2}$ to 9 ounces of zinc to the pound of copper. With additional zinc the metal becomes hard and more crystalline; with less it is more tenacious and hangs to the file like copper. The metals seem to mix well in all proportions.

With mercury, zinc unites readily to form a definite crystalline amalgam having the formula Zn_2Hg, which is soluble in mercury in all proportions. Zinc amalgam is not acted upon by dilute sulphuric acid, hence the practice of coating the zinc plates of galvanic batteries with mercury, which prevents solution of the zinc plate until the circuit is closed.

The addition of zinc to dental amalgam alloys is said to control shrinkage and confer upon the finished filling a peculiar grayish-white color which does not alter, rendering it suitable for fillings in exposed positions. (For formulas of dental amalgam alloys containing zinc, see p. 813.)

With tin, zinc unites in all proportions. The zinc-tin alloy has been used for making dies, and is recommended by Mr. Fletcher as being superior to zinc alone for that purpose, for the reason that it yields a sharper and finer casting, shrinks less, and has less surface hardness; its fusing-point is also much lower than that of zinc: 2 parts zinc to 1 part tin are recommended as the best proportions. Richardson[1] gives the formula for a zinc-tin alloy consisting of 4 parts zinc and 1 part tin as a suitable method for making dies, which has the same properties in general as the alloy recommended by Mr. Fletcher.

Lead and zinc do not unite with each other except to a very limited extent. If the two metals be melted, and even if intimately stirred together in this condition, it will be found that after they have been allowed to slowly cool union has not taken place, but the two metals are in separate layers in the order of their specific gravity, the lead, which is much heavier, being at the bottom. Analysis of each layer shows that the zinc has taken up only from one-fourth of 1 per cent. to 1.2 per cent. of lead, while the lead has alloyed with about the same quantity of zinc. The accidental mixing of lead and zinc in the dental laboratory frequently occasions vexatious delays, as when such a mixture is poured into the sand matrix the lead, from its specific gravity, sinks to the bottom, and occupies the most prominent portions of the alveolar ridge, where by reason of its extreme softness and want of rigidity it renders the swaging of a plate upon it practically impossible. Such an accident is often not discovered until the lead counter-die is cast, when if the lead is cast at a temperature much above its fusing-point, which is frequently the case, adhesion of the die and counter is sure to occur.

Lead and zinc may be separated by casting the mixture in a tall mould, and after cooling the lead, which is found at the bottom of the casting, may be cut off with a chisel; but it is preferable to reject such a mixture as soon as the fact is known, and substitute new zinc which is pure.

The lack of affinity between zinc and lead is turned to practical account in desilvering lead by Parkes's process. (See section on Silver.) Silver unites readily with zinc to form a nearly white malleable alloy when the proportion of zinc does not exceed two-thirds of the entire weight of alloy.

Platinum may be dissolved in melted zinc, the union being quite energetic, owing to the formation of a definite compound; the alloy is hard and brittle. Upon acting upon such an alloy with any of the mineral acids, the platinum may be recovered in a finely-divided state (platinum-black), suitable for solution in aqua regia.

Gold and zinc unite readily: the alloy has a specific gravity greater than the mean of its constituents. The malleability of gold is impaired by the addition of zinc. Its color is heightened by small additions, but larger amounts of zinc destroy the brilliancy and character of its color. Dr. Hermstadt's imitation of gold consists of 16 parts platinum, 7 parts copper, and 1 part zinc. This alloy is said to resemble gold closely, not only in color, but in specific gravity and ductility.

Compounds of Zinc.—Zinc oxide, ZnO, is found native as the mineral zincite, but in this state is impure, being contaminated with oxides of

[1] *Mechanical Dentistry*, p. 142.

iron and manganese. In its pure state it is much used in dentistry for the formation of two important compounds which are used as filling materials—viz. the oxychloride and oxyphosphate of zinc.

Zinc oxide is produced by the combustion of metallic zinc in air, under which conditions it forms in perfectly white, light, flocculent masses, in which form it was known to the older chemists as the *lana philosophica* or *nihilum album;* when heated the zinc oxide assumes a yellow color, but becomes pure white again upon cooling. The zinc oxide which is used as the basis for either the oxychloride or oxyphosphate must be of an extremely dense variety, and entirely free from water and carbonic acid. To obtain it in this condition the best quality of zinc oxide—preferably Hubbuck's English—is calcined at a bright red or white heat from one hour to an hour and a half in a porcelain or French clay crucible. After cooling, the semi-vitrified mass is broken up and ground in a mortar to an impalpable powder; or metallic zinc may be dissolved in nitric acid, and the solution evaporated to dryness, after which the solidified mass of zinc nitrate may be ignited, as in the foregoing process. Either method yields an exceedingly dense variety of zinc oxide.

Zinc chloride is prepared by acting upon the metal with chlorine gas or by dissolving it in hydrochloric acid and evaporating the solution to dryness. Zinc chloride thus obtained is an opaque white solid highly deliquescent, which besides its use for the production of the oxychloride cement filling is used in dental practice as an escharotic, antiseptic, stimulant, and disinfectant.

Oxychloride-of-zinc cement is made by moistening the dense oxide of zinc powder, prepared as before noted, with a solution of the chloride varying in strength from the deliquesced crystals to a 50-per-cent. solution. The cement is denser, however, when the stronger solution is used.

The oxide of zinc is colored to meet the demands of various cases by adding to it powdered rutile, the native titanium oxide, or powdered slate, etc. Silica, ground glass, alumina, borax, etc. are sometimes added with a view to improve its density and wearing qualities, but their value is questionable.

Oxyphosphate of zinc is a basic compound of zinc with phosphoric acid, made by adding a syrupy solution of glacial phosphoric acid to the dense variety of zinc oxide obtained by calcination. Its physical properties previous to setting are different from those of the oxychloride under the same conditions, in that it is of a plastic, putty-like nature that renders it more easy of manipulation and introduction.

Both of these cements, when finally prepared for introduction into the cavity, consist of a true chemical combination of chloride and oxide of zinc in the first instance, and oxide of zinc and phosphoric acid in the second, with an excess of zinc oxide in each case which is mechanically held together by these compounds respectively.

The rapidity with which crystallization or setting of the oxyphosphate takes place is entirely controllable by the degree of hydration of the phosphoric acid. When setting proceeds too rapidly, it indicates an excess of water in the phosphoric acid, which may be readily removed

by rapidly boiling the liquid in a porcelain capsule or test-tube until the proper degree of concentration is reached.

Detection of Zinc.—On charcoal before the blowpipe metallic zinc volatilizes and burns, forming an incrustation or coating of oxide, which is yellow while hot, becoming white on cooling.

Ammonium sulphide, NH_4HS, produces a white precipitate of zinc sulphide which is insoluble in acetic acid, but readily soluble in hydrochloric acid. As zinc sulphide is the only white precipitate caused by ammonium sulphide, with the exception of aluminum hydrate, which is also white and thrown down by the same reagent, this test is highly characteristic. To distinguish between aluminum and zinc hydrates add liquor ammonia to a solution of any zinc salt; a white precipitate of zinc hydrate is thrown down which is soluble in an excess of ammonia. Aluminum hydrate is insoluble in excess of ammonia.

Cadmium.

Symbol, Cd. Atomic weight, 111.6.

Cadmium is a metal closely resembling zinc in its chemical properties, and often found associated with it in its ores. The zinc ores of Silesia contain as much as 5 per cent., and in these it was discovered in 1817 by Herrmann and Stromeyer, who gave it the name "cadmium," from cadmia, the ancient name for zinc ore. Being more volatile than zinc, it passes over first in the form of a vapor during the process of reduction of the latter metal, and may be easily separated from the first portions of the distillate by dissolving the mixed zinc and cadmium in acids and precipitating the cadmium in the metallic condition by means of zinc plates, or the mixture of zinc and cadmium is dissolved in dilute sulphuric acid, and sulphuretted hydrogen conducted into the solution, which precipitates all the cadmium as yellow cadmium sulphide. This is washed and dissolved in strong hydrochloric acid, and converted into cadmium carbonate by the addition of ammonium carbonate. The cadmium carbonate after being washed and dried is distilled with carbon in the same manner as for the reduction of zinc, yielding metallic cadmium in a pure state.

Cadmium is a white, tenacious, and tolerably soft metal, lighter in color than zinc, but more easily fusible, heavier, and more volatile than that metal. It is malleable and ductile at ordinary temperatures. In hardness it is between tin and zinc. At 82° C. it becomes brittle, and crackles when bent like tin. Its specific gravity is 8.6. It fuses at 315° C. and boils at 860° C. It crystallizes in regular octahedra upon cooling from a state of fusion. Its electrical conductivity is inferior to that of zinc. It is unalterable in the air. When strongly heated with free access of air it burns, producing brown fumes of oxide. It is difficultly soluble in dilute sulphuric and hydrochloric acids, but dissolves readily in nitric acid. The chemical energy of cadmium is less than that of zinc, hence the latter metal is capable of replacing it in its compounds and precipitating it in a metallic condition.

Cadmium has been used in the formation of dental amalgam alloys,

to which it imparts the remarkable property of malleability. Its first use in this connection is attributed to Dr. Evans of Paris in 1848, the alloy he used being tin with a small proportion of cadmium.[1] Amalgam alloys containing cadmium have been so repeatedly condemned on account of the rapidity with which disintegration takes place that their use has become obsolete. The yellow sulphide of cadmium which forms upon and around fillings of such alloys permeates the tooth-structure and the tooth rapidly disintegrates. (See section on Amalgam Alloys.)

An alloy of 3 parts cadmium, 15 of bismuth, 8 of lead, and 4 of tin fuses at 140° F.

The principal compounds of cadmium are its sulphide and oxide.

Cadmium sulphide, CdS, is precipitated from cadmium salt solutions by hydrogen sulphide as a bright-yellow powder which is insoluble in dilute acids. It is employed as a pigment under the name of cadmia. Native cadmium sulphide constitutes the mineral greenockite, which is found in Renfrewshire, Scotland. It is pure crystallized cadmium sulphide, having the formula CdS, and contains 77.77 per cent. of cadmium; the remainder is sulphur.

Cadmium forms but one oxide, CdO. It is produced by combustion of the metal in air, and when in fine powder is of a reddish-brown color. When prepared by igniting the nitrate, cadmium oxide is a powder of brownish-black color, consisting, as seen under the microscope, of minute octahedra. Cadmium iodide, CdI_2, is used in photography.

Detection of Cadmium.—On charcoal before the blowpipe metallic cadmium, its sulphide, and oxide yield a characteristic reddish-brown coating of oxide on the support. Hydrogen sulphide or ammonium sulphide causes a characteristic precipitate of yellow cadmium sulphide, CdS, when added to solutions of cadmium salts. Cadmium sulphide is insoluble in an excess of ammonium sulphide or potassium cyanide, but soluble in hot nitric acid. Cadmium in solution in the presence of zinc may be detected by adding potassium hydrate in excess, when cadmium hydrate will be thrown down, which is insoluble in potassium hydrate. The zinc hydrate, which was at first precipitated with the cadmium hydrate, being soluble in potassium hydrate, will be found in the filtrate, and its presence may be demonstrated, after filtering off the cadmium hydrate, by adding ammonium sulphide to the filtrate, which precipitates the characteristic white zinc sulphide.

Bismuth.

Symbol, Bi. Atomic weight, 210.

Bismuth was apparently known to Basil Valentine in the fifteenth century, but was first described by Agricola in 1529, who called it bisemutum. It is a comparatively rare metal, found chiefly in Saxony, Transylvania, and Bohemia, though it is found in smaller quantities in Norway and Sweden, some parts of England, the United States, and lately in South America (Peru). It is generally found in the metallic

[1] *Practical Dental Metallurgy*, p. 71, Thomas Fletcher.

state, associated with ores of cobalt, nickel, copper, and silver. It occurs as an oxide, forming the mineral bismite; as sulphide, or bismuthinite; as carbonate, or bismutite; and as sulpho-telluride, or tetradymite. It is generally extracted from the gneiss or clay slate and other rocks in which it occurs in veins in the metallic condition. At Schneeberg in Saxony, where the extraction of bismuth is chiefly performed, the ore, which contains from 7 to 12 per cent. of the metal, is broken into small pieces and introduced into cast-iron cylinders placed in a furnace in an inclined position, where they are heated by a wood fire. The lower end of the cylinder is closed with a fireclay stopper having an opening, through which the fused bismuth runs out. The upper end of the cylinder has an iron door, through which the spent charge is raked out and fresh ore introduced, so that the process proceeds with but slight interruption. Bismuth fuses quite readily, its melting-point being 264° C., so that in a few minutes after the charge of ore is heated up the metal commences to run from the opening in the lower end of the cast-iron cylinder into an iron pan containing some coal-dust, which floats upon the surface of the metal and prevents loss by oxidation. The iron receiving-pan is kept hot by a separate fire. From these pans the metal is ladled out into ingot-moulds.

Thus obtained, bismuth contains considerable amounts of arsenic, iron, and sometimes silver. It is freed from the greater part of the arsenic by heating the metal strongly in crucibles with charcoal, to prevent oxidation when the arsenic is expelled as vapor; or the metal is sometimes purified by fusion with potassium nitrate, which removes arsenic, iron, and sulphur by oxidation. When silver exists in the metal in an amount to warrant it, the commercial bismuth is cupelled in the same manner as lead: the oxide of bismuth, which is removed like the litharge when lead is cupelled, is afterward reduced to the metallic state by ignition with carbon. Chemically pure bismuth may be obtained by reducing the basic or subnitrate of bismuth with carbon.

Bismuth is a highly crystalline metal, hard and brittle, and of a brilliant reddish-white lustre, generally iridescent, owing to a slight superficial film of oxide. Its specific gravity is 9.83, and its crystalline form is the rhombohedron, though the crystals, on account of their wide interfacial angle, 87° 40′, have frequently been mistaken for cubes, the angle of which is 90°. Crystals of large size and great beauty may be obtained by melting several ounces of bismuth in a crucible or ladle, allowing it to cool until a crust has formed, and then piercing it and pouring out the still fluid contents. Bismuth is easily fractured by a blow with the hammer, but is not quite so brittle as antimony. Two properties of bismuth distinguish it from all other metals: first, that of expanding on passing from the fluid to the solid state—a quality which it imparts to many of its alloys; and second, its power of reducing the fusing-point of all alloys of which it is a constituent. It has been found that bismuth expands one thirty-second of its bulk in solidifying from the melted condition. It has been found also that its specific gravity is decreased when the metal is subjected to strong pressure.

The uses of bismuth in alloys depend upon the fusibility and power of expanding in solidifying which it imparts to them.

The power which bismuth possesses of reducing the fusing-point of alloys is remarkable, and is independent of, and not accountable for on the ground of, its own low fusing-point.

Rose's fusible metal is composed of lead. 1 part; tin, 1; bismuth, 2 parts. This alloy fuses at 94° C. or 201.2° F.

Wood's metal, fusing below 158° F., upon analysis consisted of—

	Parts. I.	II.	III.	IV.
Bismuth	49.87	49.89	49.81	49.72
Lead	26.81	26.73	26.80	26.90
Tin	13.25	13.36	13.53	13.41
Cadmium	10.13	9.93	9.69	10.10[1]

According to Lipowitz, an alloy consisting of 3 parts of cadmium, 4 of tin, 8 of lead, and 15 of bismuth becomes soft between 122° and 140° F., and entirely liquid at 140° F.; while Wood found that the mixture most easily fusible became sufficiently liquid for casting purposes at 159.8° F., and congealed at 150° F., and therefore he fixed its melting-point as between 150° and 159.8° F. The following proportions give the lowest melting-points in both cases—150° F. or very close to it:

	Parts.	
Bismuth	4	3
Lead	2	4
Tin	1	8
Cadmium	1	15

Similar alloys are used as solder for pewter and alloys of tin and lead. The following composition gives satisfactory results: Tin, 30 parts; lead, 15; and bismuth, 3 to 9.

Some kinds of type- and stereotype-metal have bismuth as an ingredient in their composition. Such alloys expand at the moment of solidification, and are thus forced into the finest lines of the mould, yielding extremely sharp and fine castings. An alloy consisting of 8 parts bismuth, 5 lead, 4 tin, and 1 type-metal constitutes the fusible alloy used on the Continent for producing the beautiful casts of the French medals by the *clichée* process. The metals should be repeatedly melted and poured into drops until they are well mixed.

Bismuth has been employed when alloyed with zinc for the formation of dies in the dental laboratory, the zinc-bismuth alloy having a lower fusing-point than pure zinc, and being free from contraction on cooling.

Wood's metal, an alloy sometimes used by dentists for replacing teeth on vulcanite plates, is composed of bismuth 7 parts, lead 6, and cadmium 1: it fuses at 180° F. (82° C.). A dovetail is cut in the plate with a saw or file, and the tooth fitted in position, after which the fusible alloy is moulded into the joint with a hot instrument, and the surface afterward smoothly finished.

All of these alloys are rendered still more fusible by the addition of a small amount of mercury.

The effect of bismuth in dental amalgam alloys does not seem to

[1] *Techno-chemical Receipt-Book*, Brannt-Wahl.

have been fully studied. Mr. Fletcher states:[1] "The addition of bismuth to amalgams makes them excessively sticky and adhesive, necessitating at the same time an increase in the proportion of mercury required. Amalgams containing a trace of bismuth will build and adhere to a flat dry surface, and may be used as a metallic cement for joints in apparatus which requires to be perfectly air-tight and to stand heavy pressures. A good alloy for this purpose is 1 part bismuth, 15 tin, 15 silver, fused and filed up, and then mixed in the proportion of 1 part alloy to 4 of mercury." This alloy is stated to be "so excessively sticky as to be useless for fillings."

An alloy of 3 parts each bismuth, fine gold, and platinum, with 15 of fine silver and 10 of tin, is said to be very similar to precipitated palladium, and has been used as a substitute for it, though if the alloy contains but a trace of palladium it is said to be worthless; and Mr. Fletcher therefore directs that it be made only with silver reduced directly from the chloride, as ordinary fine silver is rarely if ever free from traces of palladium.

It would seem that the power of bismuth to overcome the contraction of alloys in solidifying would render it valuable as an ingredient in certain dental amalgam alloys if it conferred no objectionable qualities other than adhesiveness upon them; but, so far as the author can ascertain, with the exception of Mr. Fletcher's experiments no record of investigations by others in this direction has been made.

The compounds of bismuth are not poisonous. Bismuth is but slightly altered in the air at ordinary temperatures. Strongly ignited, it burns to bismuth oxide, Bi_2O_3. At a white heat, with exclusion of the air, it may be distilled. It is soluble in nitric acid and boiling sulphuric acid, but insoluble in hydrochloric. Its chloride, $BiCl_3$, is obtained by the direct action of chlorine on the metal or by solution in aqua regia. It is a soft, white, fusible, and deliquescent mass, which when added to water is converted into the insoluble oxychloride of bismuth, $BiOCl$. Its oxide, Bi_2O_3, is a yellow powder insoluble in water and alkalies obtained by burning the metal or by the ignition of its nitrate. Bismuth nitrate, $Bi(NO_3)_3$, is obtained by the solution of bismuth in nitric acid; it crystallizes with five molecules of water in large transparent tables. In a small quantity of water it dissolves without change. Much water decomposes it, forming the basic or subnitrate of bismuth, $BiONO_3$, an officinal compound much used in medicine and as a cosmetic under the name of pearl white or *blanc de perle*. Bismuth sulphate is formed when the metal is dissolved in sulphuric acid; it crystallizes in delicate needles, and is decomposable by water, forming oxysalts, which peculiarity is characteristic of nearly all the salts of this metal. Bismuth sulphide, Bi_2S_3, which occurs native as bismuthinite, is thrown down as a black precipitate from bismuth solutions by hydrogen sulphide. It is insoluble in excess of ammonium sulphide.

Detection.—Hydrogen or ammonium sulphide produces a black precipitate of bismuth sulphide in bismuth solutions, which is insoluble in dilute acids and alkalies, but soluble in boiling nitric acid. Alkaline

[1] *Practical Dental Metallurgy*, Thomas Fletcher, F. C. S.

hydrates throw down a white precipitate of bismuth hydrate, $Bi(OH)_3$, which upon boiling is converted into the yellow oxide. Potassium iodide gives a brown precipitate of bismuth iodide, BiI_3, soluble in excess of the reagent. Alkaline carbonates throw down the white oxy-carbonate of bismuth, $(BiO)_2CO_3H_2O$. Water added in excess to make neutral solutions of the nitrate or chloride throws down the white basic or subnitrate and oxychloride of bismuth, respectively.

On charcoal before the blowpipe bismuth forms a hard bead of metal with a characteristic coating or incrustation of oxide, deep orange-yellow while hot and pale when cold.

Determination.—Bismuth is estimated as metal, as chromate, oxide, sulphide, or oxychloride. (For details of the methods applicable in each instance see works on chemical analysis.)

Aluminum.[1]

Symbol, Al. Atomic weight, 27.5.

This element, which is the metallic basis of mica, feldspar, slate, clay, and nearly all rocks with the exception of limestones and sandstones, is the most abundant metallic element in the earth's crust. Corundum and emery are its oxides, which in many instances are nearly pure. It also forms the basis of the ruby, emerald, sapphire, and topaz, which are used as gems, and is found in the composition of nearly two hundred different minerals. Its oxide, alumina, Al_2O_3, was for a long time confounded with lime, from which substance it was distinguished by Marggraff in 1754, up to and some time subsequent to which date the oxides of calcium, aluminum, and the alkali earth-metals were regarded as elementary bodies. The French chemist Lavoisier about 1781, seven years after the discovery of oxygen by Dr. Priestley, evolved the chemical theory of combustion and predicted the compound nature of these substances. Acting upon the prediction of Lavoisier, that the alkaline earths and fixed alkalies were the oxygen compounds of metallic bases, a number of distinguished chemists attempted their reduction. Prominent among these was Sir Humphry Davy, who in 1807 succeeded in obtaining the metals potassium and sodium from their oxides by aid of the galvanic current, and during the year following the metals barium, calcium, and magnesium were similarly reduced by him. Alumina had thus far resisted all attempts at decomposing it. In 1826 the Danish chemist Oersted first prepared the chloride of aluminum, but failed to decompose it. The metal was first obtained by Professor Wöhler of Göttingen in 1828: he accomplished this by acting upon aluminum chloride with metallic sodium. Wöhler's process was placed upon a commercial basis, and so far improved by St. Claire Deville in 1854 that considerable amounts are produced by his process, though the price, about $32 per pound, precludes its use for many purposes to which its remarkable physical properties make it especially applicable.

[1] Spelled also *aluminium*. Common usage has sanctioned the employment of either term to designate this metal, though from an etymological standpoint the term *aluminum* would seem preferable.

The metal was first produced from cryolite, the native sodium, and aluminum fluoride by H. Rose in 1855. Various modifications and improvements in the methods of reducing aluminum have been made since its discovery by Wöhler, which have constantly and steadily reduced the cost of the metal until the price may be now said to have come within the reach of the manufacturing arts. A most important advance in the metallurgy of aluminum and analogous refractory substances has been made through the invention of the electrical furnace of Eugene H. and Alfred H. Cowles of Cleveland, Ohio. The essential and novel feature of the Cowles furnace consists in the application of the intense heat obtained by the passage of a powerful current of electricity from a dynamo machine through a conductor of great resistance in the presence of carbon, by which means the most refractory ores are decomposed with liberation of their metallic bases, some of which have hitherto resisted all similar attempts at reduction.

The crushed ores are mixed with fine charcoal, and for the production of alloys with fragments of copper or some other metal, and placed in a rectangular box of firebrick lined with limed charcoal, which prevents loss of heat by radiation and protects the firebrick from disintegration. The cover of the furnace is a cast-iron slab. Surrounding the charge on all sides is a layer of fine charcoal, which prevents contamination of the metal with calcium from reduction of the lime in the limed charcoal lining. After the charge is introduced the top of the furnace is luted on, and the current from a powerful dynamo-electric machine is passed into the furnace by means of two large electric-light carbons, termed electrodes, which pass through the ends of the furnace and into the charge. When the current has passed for about five hours the furnace is allowed to cool and the contents removed.

For the production of aluminum bronze the charge is made up of about 50 pounds of copper, 25 pounds of crushed corundum (aluminum oxide), and 12 pounds of a mixture of charcoal and electric-light carbon. The products of the reduction consist of about 50 pounds of a copper alloy containing 15 to 35 per cent. of aluminum and a small quantity of silicon. This compound is found to occupy the lower portion of the furnace, and from it is made standard aluminum bronze alloys containing from 5 to 10 per cent. of aluminum by remelting it with the proper amount of copper. Higher up in the furnace is found a grayish fused mass that consists of aluminum and carbon (probably a carbide), the latter element being present in quantities varying from 30 to 60 per cent.

The chemistry of the process, so far as understood, is simple. The carbon, aided by the high temperature, removes the oxygen from the corundum, with formation of carbon monoxide. A small amount of aluminum is obtained in grains mixed with charcoal; another portion unites with copper to form the alloy; while the remainder unites with carbon to form the grayish crystalline carbide of aluminum. The heat developed is so intense that nearly all oxides are reduced and charcoal is changed to graphite. It is possible that electrolysis plays some part in the operation, but no proof has yet been given that it does, and the reduction is believed to be simply the result of the action of carbon on the high temperature developed by the resistance which the charge

offers to the passage of the powerful current. Aluminum is manufactured by an analogous process at Hamelingen near Bremen in Germany, under the patent of Graetzel, who has readopted the idea of Bunsen, to separate the aluminum by electricity. He applies a very powerful dynamo-electric current, which he conducts through molten sodium-aluminum chloride, whereby the metal is deposited at the negative electrode and chlorine is liberated at the positive electrode.

Deville's method for the production of aluminum consists in abstracting the chlorine from the double chloride of aluminum and sodium with metallic sodium, whereby the aluminum is set free. A mixture of carbon and alumina is heated with common salt to redness in an iron gas-retort into which chlorine is conducted, under which conditions oxygen is removed from the alumina by the carbon and aluminum chloride is formed, which distils over in combination with sodium chloride as double chloride of aluminum and sodium, and is condensed in the receiver. It is then mixed with the proper amount of metallic sodium and exposed to a bright-red heat in a furnace, whereby the chlorine unites with the metallic sodium to form sodium chloride, and metallic aluminum is liberated.

Aluminum may also be formed by acting in a similar manner upon cryolite, the native double fluoride of aluminum and sodium, with metallic sodium, or its fused chloride may be decomposed by the galvanic current.

Aluminum is nearly white in color, with a lustre approaching that of silver. It is one of the lightest of the metals, having a specific gravity of 2.5. It is harder than tin, but softer than copper; its hardness is about that of pure silver. Its crystalline form is the octahedron. It is one of the best conductors of heat and electricity known. It is malleable and ductile, and may therefore be beaten into thin sheets or drawn into fine wire. It is remarkably sonorous, emitting a clear ringing tone when a bar of it is struck with a hammer. It melts at 1300° F., and is not oxidized in the air, nor is it acted upon by sulphur compounds, and is without odor or taste. It is not acted upon by concentrated or dilute nitric acid, either hot or cold; dilute sulphuric acid does not dissolve it, but it is readily soluble in hydrochloric acid or a solution of sodium or potassium hydrate, with rapid evolution of hydrogen gas.

Aluminum is used for the manufacture of the smaller weights, such as the grain or milligram, its low specific gravity rendering it particularly well adapted for the purpose. It is also used in the manufacture of various pieces of mathematical and optical apparatus. But its applications are greatly hampered by the high cost of its production at present. Its many valuable properties, especially its lightness, malleability, and conductivity, early attracted the attention of members of the dental profession to it as a material upon which to construct artificial dentures. Prominent among those who used aluminum for this purpose was Dr. J. B. Bean of Baltimore, who perfected and patented an elaborate method for constructing dentures upon the aluminum base, which can be characterized as a triumph of inventive skill, for the inventor succeeded in producing plates by a cheoplastic process by which the resulting castings were of exquisite fineness, and the obstacles in the way of produ-

cing fine castings of aluminum were at that time many and difficult to overcome. The great difficulty, however, and the one that finally caused the abandonment of the cast metal as a base for artificial dentures, was a chemical rather than a physical one—viz. the solubility of aluminum in alkaline solutions, which effected the corrosion and decomposition of dentures made upon it in a few months.

The difficulty of casting aluminum depends upon its specific lightness and its pasty nature or lack of fluidity when melted, which cause it to flow sluggishly or with difficulty into the finer parts of the mould. Bean succeeded in overcoming this by using tall conduits lined with fire-clay, which were attached to the gates of his flask, and through which the metal was poured after bringing the flask with its contents to an elevated temperature. The pressure of the column of metal in the tall conduit caused the metal to fill out all of the irregularities of the mould.

Recently, Dr. C. C. Carroll of Meadville, Pa., has devised a process whereby very fine castings of aluminum may be obtained by pneumatic pressure. The metal is melted in a plumbago crucible of special construction. It has the general form of a thick-walled cylinder closed at one end, which serves as a bottom. A channel is formed within the wall of the crucible, one orifice of which terminates within the crucible at the side and close to the bottom. Starting from this orifice, the channel rises in the crucible wall to near the top, making a sharp return upon itself, and descends in a parallel course after the manner of a siphon, and makes its exit at the base and near the side of the crucible. Here it terminates in an iron nipple that fits into a corresponding socket in the gateway of the moulding-flask. A cylindrical plug of soapstone, which fits the open mouth of the crucible, is provided with a central tube of brass, to the free end of which is connected by a short length of rubber tubing a large rubber bulb. When the metal has been brought to a state of fusion and the crucible connected by means of the iron nipple at its base with the gateway of the flask, which has been previously heated to near redness, the soapstone plug is inserted in the mouth of the crucible and the rubber bulb is steadily but forcibly compressed. The atmospheric pressure forces the fluid metal out through the siphon-like channel and into the minutest lines of the mould, yielding a fine casting; but in this, as in Bean's process, the contraction of the metal on cooling almost invariably causes fracture of the teeth, or the shrinkage will show itself in portions of the plate, causing objectionable, or at least unsightly, defects.

Where the rolled aluminum plate is used as a base upon which teeth are mounted by a vulcanized rubber attachment, disintegration does not proceed so rapidly as in the case of the cast plates made by Bean's method. This, in the opinion of Prof. Essig,[1] is due to the fact that by the process of Bean the teeth are fastened to the cast aluminum plate by means of tin or an alloy of aluminum and tin, which causes and maintains a galvanic action between the metals which hastens the disintegration of the aluminum plate, as some of the dentures made by Bean failed after a few months' wear. It is highly probable that the impurities which generally exist in commercial aluminum are also fac-

[1] *Dental Metallurgy*, p. 230.

tors in the disintegration of dental plates made from it. According to Dr. Rammelsberg, commercial aluminum always contains silicium and iron, the former in quantities of from 0.7 to 10.46 per cent., and the latter from 1.6 to 7.5 per cent.

Alloys.—Aluminum forms alloys with nearly all metals except lead. From the experiments of Professor Thomas H. Chandler of Boston[2] and Professor Henry Wurtz, it appears to form an unstable amalgam with mercury.

1 per cent. of aluminum in gold yields an alloy which is very hard, but not ductile, and of a green color, similar to the green gold formed by alloying gold with silver. 5 per cent. of aluminum with gold yields an alloy brittle as glass. 10 per cent. of aluminum with gold furnishes a white, crystalline, and brittle alloy.

Silver and aluminum are easily alloyed, the resulting metal being harder than aluminum, but more easily worked. 3 per cent. of aluminum in silver produces an alloy which is but slightly if at all affected by the sulphide of ammonium. 5 per cent. of aluminum with silver gives a hard, white, elastic alloy which is used for the blades of dessert- and fruit-knives. . The alloy known as *tiers argent*, used in France for the manufacture of forks, knives, and tableware, is composed of aluminum 1 part with silver 2 parts; it has a beautiful color and lustre, and is not blackened by sulphur or its compounds. Equal parts of aluminum and silver furnish an alloy which has the hardness of bronze.

The addition of aluminum to tin increases its hardness and elasticity. From 3 to 5 per cent. of aluminum forms the most useful alloys; they are but little affected by acids.

Zinc and aluminum easily unite, and a number of the zinc alloys of aluminum are used as solders for the latter metal. In preparing them the aluminum is first melted and the zinc added gradually, after which some fat or cosmoline is added to prevent oxidation, and the alloy is cast into moulds after rapid stirring with an iron rod. The following alloys are used as solders:

	I. Parts.	II. Parts.	III. Parts.	IV. Parts.
Zinc . . .	80	85	88	92
Aluminum	20	15	12	8

The flux used in soldering with these alloys consists of a mixture of 3 parts copaiba balsam, 1 part Venetian turpentine, and a few drops of lemon-juice. The soldering-iron is dipped into this mixture.

William Frishmuth of Philadelphia, who has spent a number of years in perfecting processes for the reduction of aluminum, has devised and recommends the following alloys for soldering aluminum; the flux used is vaseline:

		I.	II.
Soft Solder.	Pure block tin, from	99 parts to	90 parts.
	Bismuth . . . "	1 " "	10 "

		I.	II.
Hard Solder.	Pure block tin, from	98 parts to	90 parts.
	Bismuth . . . "	1 " "	5 "
	Aluminum . . "	1 " "	5 "

[1] *Dental Cosmos*, vol. viii. p. 358, and vol. x. p. 222.

The above formulas are successfully used by Tiffany & Co. of New York and others for soldering articles of jewelry made from aluminum.

Perhaps the most interesting and valuable alloy of aluminum is its copper combination. When added in the proportion of from $2\frac{1}{2}$ to 10 per cent. to copper, a bronze is produced which is remarkable for its physical properties. Its tensile strength is many times greater than that of copper, that of the 10-per-cent. bronze reaching nearly 110,000 pounds to the square inch. It is tough and elastic, having the texture and toughness of soft steel, and sufficient elasticity for the manufacture of certain kinds of springs. It does not corrode or tarnish in the atmosphere; its color approaches that of 18-carat gold so closely that it is used in the manufacture of cheap jewelry; it is also remarkably free from any brassy odor or taste. It may be worked either hot or cold, and is generally conceded to be the most valuable and useful bronze alloy known. It is used in France for the manufacture of many surgical-instrument handles, etc., and does not tarnish in use.

The following solders may be used for small articles and jewelry work of aluminum bronze:

I. *Hard Solder for 10-per-cent. Aluminum Bronze.*

Gold	88.88	per cent.
Silver	4.68	" "
Copper	6.44	" "
	100.00	

II. *Medium Hard Solder for 10-per-cent. Aluminum Bronze.*

Gold	54.40	per cent.
Silver	27.00	" "
Copper	18.00	" "
	100.00	

III. *Soft Solder for Aluminum Bronze.*

Brass (Copper . . 70 per cent.; Tin . . . 30 " ")	14.30	per cent.
Gold	14.30	" "
Silver	57.10	" "
Copper	14.30	" "
	100.00	

The melting-point of 10-per-cent. aluminum bronze is somewhat less than that of copper, and its specific gravity is 7.23. The addition of small amounts of aluminum to brass greatly increases its toughness, elasticity, and tensile strength. An alloy of zinc, copper, and aluminum has been recently introduced in Germany as a material for use as a dental base. It is said to be unaffected by the oral fluids.

Iron and aluminum unite very readily, so that the surface of iron rods, etc. may be coated with a lustrous film of aluminum in much the same manner that tin is applied to iron. Ostberg, a Swedish inventor, has lately discovered that the addition of a minute quantity of aluminum to wrought iron greatly increases its fusibility, so that castings may be made from it as readily as from the highly carbonized cast iron. His method of procedure is to heat wrought-iron scrap in a crucible to a white heat or until it assumes a pasty condition, and then introduce the aluminum in the form of an alloy of iron and aluminum, the result being that the mass almost instantly becomes thinly fluid, the fusing-

point being lowered about 500° F. The surplus heat which it now contains beyond the amount required for fusion is sufficient to keep it thoroughly fluid during the operation of casting. The addition of aluminum necessary to produce this remarkable effect does not exceed one-fiftieth of 1 per cent., and does not interfere with the physical properties of the result, so that the production of many articles of wrought iron which could only be accomplished by the tedious and expensive method of forging can be manufactured with much greater facility and cheapness by the simple process of casting.

Compounds.—Aluminum chloride, $Al_2{}^{vi}Cl_6$, is a colorless, semi-crystalline, waxy substance, fusible and volatile, prepared by passing chlorine gas over a heated mixture of alumina and carbon. Aluminum oxide or alumina, Al_2O_3, occurs native as corundum, which includes the gems ruby and sapphire; it is the hardest substance in nature with the exception of the diamond, and is used extensively for grinding and polishing hard substances. Emery is a massive variety of the same composition, used for the same purpose. Alumina may be prepared artificially by combustion of aluminum or by igniting the hydrate obtained by precipitating any aluminum salt with ammonium hydrate. Aluminum sulphate, $Al_2(SO_4)_3$, prepared by acting upon the hydrate with sulphuric acid, is used as a mordant in dyeing.

The most important salts of aluminum are its double sulphates or so-called alums; of these there is a large class composed of sulphate of aluminum with sulphates of sodium, potassium, ammonium, iron, manganese, chromium, etc., and designated as ammonia-, potash-, iron-, or chrome-alum, as the case may be.

Ammonium hydrate produces in all solutions of aluminum salts a white precipitate of aluminum hydrate, $Al_2(OH)_6$, which is not soluble in an excess of the precipitant.

ELECTRO-METALLURGY.

A few isolated phenomena pertaining to the electro-deposition of metals were observed at a very early period: thus it was known that iron or steel when dipped into a solution of blue vitriol became coated with a film of copper, and the analogous decomposition of salts of silver and of lead by zinc and copper, resulting in the formation of metallic crystals of silver and lead, were familiar to the alchemists as the *arbor dianæ* and *arbor saturni* respectively. But the true electrolysis of metallic solutions may be safely said to be coincident with, and to have had its origin in, the discovery of chemical electricity by Volta in 1799, about which time he produced his famous crown of cups, the first arrangement by which a current of voltaic electricity could be maintained for any considerable length of time. Soon after this Wollaston announced that if a piece of silver in connection with a more positive metal be placed in a solution of copper, the silver is coated with a film of copper sufficiently coherent to stand the operation of burnishing. Following the discovery of Wollaston came the investigations of Hisinger and Berzelius upon the influence of the voltaic current upon water and neutral salts, and about the same time they experimented upon the

electrolysis of argentic nitrate, cupric sulphate, lead acetate, and several other metallic salts, and found that the metals were deposited at the negative or zinc pole of the battery; and from this fact they suggested the electrolytic analysis of minerals.

Brugnatelli in 1805 successfully gilded two silver medals by making them the negative pole in a newly-made and strong solution of auric chloride in ammonia. In 1807 followed the great discoveries of Sir Humphry Davy, who isolated the metallic bases of the caustic alkalies by means of a powerful current from two hundred and seventy-four cells.

In 1831, Michael Faraday discovered magneto-electricity. He found that a spark was produced by suddenly pulling off the keeper from an electro-magnet, and he obtained a current of magneto-electricity by causing a copper plate to rotate between the poles of an electro-magnet.

In 1836, De la Rue observed that the copper plate in a peculiar form of Daniell's battery which he had devised was having copper continuously deposited upon it, and that upon stripping off the deposited film of copper an exact counterpart of the surface of the copper electrode was obtained, every scratch being faithfully reproduced. In 1839, Jacobi of St. Petersburg, Spencer in Liverpool, and Jordan in London independently developed from this fact a method of obtaining by the electrolysis of sulphate of copper relief impressions of coins, stereotype plates, ornaments, etc. In 1840, Mr. Murray communicated to the Royal Institution an important addition which he had made to the art of electro-metallurgy, which consisted in coating the surfaces of non-conducting materials with plumbago, which, being an electrical conductor, enabled deposits to be made upon such coated surfaces.

Up to this time the deposition of copper by electricity in the process of electrotyping had been performed by what is known as the single-cell process; that is, a Daniell's cell, which consists of a glass or earthenware vessel containing a saturated solution of sulphate of copper, having immersed in it another cell of much smaller diameter and constructed of unglazed or porous earthenware, which is filled with dilute sulphuric acid to the same height as the sulphate of copper solution in the outer vessel. A rod of cast zinc is immersed in the solution of the porous cell. The article upon which the copper was to be deposited after being perfectly cleaned if metallic, or its surface rendered conducting by a coating of plumbago if not, was attached to a copper wire and immersed in the sulphate-of-copper solution, of the outer cell: the free end of the conducting wire was then connected with the zinc rod of the porous cell, and the circuit thereby closed. By this means in the course of time a deposit of pure copper formed upon the object suspended in the sulphate-of-copper solution, which when stripped off gave a fac-simile of it in relief. In 1840, Mr. Mason devised his separate battery apparatus by which the current from a Daniell's cell was caused to effect electro-deposition in a separate vessel in which were suspended the articles to be coated, and which were connected to the positive pole of the battery, while a sheet of copper, similarly connected to the negative pole of the battery and suspended in the blue-vitriol solution of the depositing tank or vessel, completed the circuit. In this

arrangement as fast as the metal is removed at the negative pole from the solution by articles being coated, an equal amount dissolves from the copper plate forming the positive pole, and the solution is maintained at a uniform strength. Modifications of this arrangement soon followed by which any regular source of electricity was substituted for the current from a single Daniell's cell.

Electro-metallurgy has three general applications in the arts—viz. 1. The reduction of metals from solutions of their ores, which is at present limited in its application owing to the costliness of methods for producing electricity: it is, however, of considerable value in the exact analysis of certain metallic ores; 2. The copying of type, plaster casts, etc. by electro-deposits of copper, termed electrotypy; and 3. The coating of base metals with films of another metal, such as gold, silver, nickel, etc., which process is termed electro-plating.

While the principles involved in the processes of electrotypy and electro-plating are in many respects identical, the results attained differ, in that by the former the object is to obtain a copy of the object—for example, a plaster cast, coin, or work of art which is separate and distinct from the object operated on—while in the latter the object is coated with a film which is adherent to and inseparable from the object so treated.

Electrotypes of copper are those most commonly made, from the low electro-motive force required for the electrolysis of its sulphate. They are made by suspending a suitable mould, the surface of which has been rendered conducting by a coating of plumbago, in a saturated solution of sulphate of copper, and passing a current from a battery or other source of electricity through the solution, the mould being connected by a copper wire to the negative or cathode element of the battery, and a plate of copper similarly suspended in the solution and connected to the positive or anode. The action commences at the moment the circuit is formed, and copper is dissolved from the anode plate in an amount and at a rate exactly equal to the rate of deposition at the cathode. This process is largely used for copying type, wood engravings, etc., for which purpose a cast in plaster of Paris is taken of the engraved wood block or type and its surface rendered conducting by a coating of plumbago: it is then connected with the battery and immersed in the copper solution. After a sufficient film has been deposited it is stripped off, and strengthened by receiving a backing of type-metal, which is cast upon its reverse side: the plate thus obtained is mounted upon a wood block and used for printing, being much more durable than the original wood engraving, of which it is an exact fac-simile.

For the reproduction of ornaments, works of art, etc. the process is exactly similar, with the exception of certain details in the reproduction of objects having undercuts or irregular projections: these are reproduced from sectional moulds, or moulds made of elastic composition composed of glue and treacle or glue and glycerin, the surface of the latter being rendered conducting by a solution of phosphorus in carbon bisulphide or a nitrate-of-silver solution followed by one of ferrous sulphate.

Objects of enormous size have been reproduced in copper by the

electrotyping process. The Messrs. Elkington in England produced in this way a statue thirteen and a half feet in height and weighing two tons, the vat in which it was formed holding over six thousand gallons of solution. Messrs. Christople of Paris made a statue in this way nine meters high, weighing thirty-five hundred kilograms, and four and a half millimeters in thickness.

For large electro-metallurgical operations dynamo-electric machines are used. These generators of electricity furnish powerful currents at a minimum cost, and depend for their action upon the principle discovered by Siemens, and independently by Wheatstone, that a coil rotating between the poles of an electro-magnet induces a small current from its feeble residual magnetism, which when transmitted through the coils of the electro-magnet induces a stronger current by exalting its magnetism, and so enables it to induce a still stronger current. Many modifications of dynamo-machines embodying this principle are in use, the most noted of which are those of Siemens, Gramme, Brush, and Edison: their chief differences are those of mechanical details and means employed for obtaining a continuous current.

Electro-plating, which had its origin in the experiments of Wollaston and Brugnatelli before noted, has for its object the coating of base metals with a protective or ornamental film of silver, gold, nickel, etc.

For electro-deposition of silver a solution of the double cyanide of silver and potassium is generally employed, and yields the best results. The solution may be made by a variety of methods, though the following gives satisfactory results: To a solution of nitrate of silver add, cautiously, a solution of cyanide of potassium until the silver is completely precipitated; avoid an excess of the precipitant, as the cyanide of silver is soluble in an excess of it. Collect the precipitated argentic cyanide on a filter, and wash thoroughly with distilled water to remove all traces of potassic nitrate which have been formed. Make a solution of from six to eight parts of potassium cyanide in twenty parts of distilled water, and add it in portions at a time to the precipitated and moist argentic cyanide first obtained, stirring freely until the whole of it is barely dissolved, after which add about three parts more of cyanide solution, and sufficient distilled water to reduce the whole to the proportion of about one ounce of silver to the gallon of solution, and filter. This solution conducts electricity well and yields a good deposit of silver with a proper current. The character of the deposited film forms the best indicator as to the strength of current necessary to be employed. If the articles become gray or black and much gas is evolved, the current is too strong, and the number of cells or the depth of immersion of the battery-plates must be diminished. When the deposition is proceeding regularly and properly, the film will present a frosted, white appearance, and the solution can be worked almost indefinitely by using a silver plate as an anode by which the original standard of silver in the solution is maintained. The solution improves in working qualities after several weeks' use. The addition of a small amount of carbon bisulphide to the plating bath causes the silver to be deposited with a bright, lustrous surface. The thickness of the deposited film on electroplated articles varies greatly. In France it is regulated by law, and the

articles are stamped by a comptroller appointed by the government, so that the exact amount of silver by weight is stamped upon each article. From an ounce to an ounce and a half will give a coating about the thickness of writing-paper to a square foot of surface.

For the electro-deposition of gold, or electro-gilding, a number of different solutions have been successfully employed, many of them quite complex in composition: the best and most uniform results are obtained, however, from solutions of gold cyanide in an excess of potassium cyanide, worked hot—that is, at a temperature of from 130° to 140° F. The preparation of such a solution is sufficiently simple, and may be accomplished as follows: A weighed quantity of pure gold is converted into auric chloride by dissolving it in aqua regia, evaporating to dryness over a water-bath, and dissolving it in a considerable quantity of distilled water. To the solution thus obtained a strong solution of cyanide of potassium is added until all of the gold is thrown down as cyanide of gold, care being taken to avoid the slightest excess of the precipitant. The gold cyanide thus formed is collected in a filter and well washed with distilled water. A strong solution of potassium cyanide is now added to the moist precipitate, a sufficient quantity being added to just dissolve it completely, and a note made of the amount required to effect this purpose. When this is done about one-fifth or one-fourth more than the amount necessary to do this of the cyanide solution is added, and the whole then diluted to the strength desired with distilled water. The strength of the cyanide gilding solution may vary greatly without materially influencing the quality of the film deposited, though moderately dilute solutions yield a better quality of metal than stronger ones, but the rate of deposition in a dilute solution is slower than in a stronger one. A convenient strength of solution is made up of one ounce of gold, sixteen ounces of potassium cyanide, and one gallon of water. In all processes for electro-gilding with a separate battery-current a gold anode is used, and the solution worked hot, as a smoother and cleaner, as well as more durable, deposit is thus obtained than one of the same thickness made in a cold solution.

The current from at least two Bunsen battery-cells is generally employed, the size of the cells depending upon the magnitude of the articles to be plated. All articles upon which gold or silver—or, in fact, any metal—is to be deposited by electrolysis must have their surfaces rendered absolutely clean by a thorough use of the scratch-brush and subsequent treatment by a solution of caustic soda or pickling in acid, as the nature of the metal to be plated will determine. It is also customary in some cases to deposit a slight film of mercury upon the surface of the article to be plated by dipping it in a so-called "quicking" solution made of some soluble mercurial salt: this ensures absolute cleanliness of surface and perfect adhesion of the gold or silver film.

Besides the gold-cyanide solutions, a solution of aurate of ammonia in cyanide of potassium is in considerable use for gilding at ordinary temperatures: the results obtained are, however, not equal to those obtained from the hot gold-cyanide solutions.

Under proper conditions gold may be thrown down from solution in crystalline form, the preparation known as Watt's crystal gold being

produced in this manner by the electrolysis of a solution of auric chloride, a gold anode being used, by which the strength of the solution is maintained and the process rendered practically continuous. Variations in the size and character of the crystals obtained by this method are produced by alterations in the strength of the solution and battery-current, as well as the temperature of the bath, etc.

Though nearly all metallic substances, as well as some alloys, may be deposited under suitable conditions by the electrical current, but a limited number have so far found useful applications in the arts: those already alluded to, with the addition of nickel, constitute the most important.

The electro-deposition of nickel upon iron and other metals constitutes an enormous branch of the art of electro-metallurgy, and, though of comparatively recent introduction, its growth has been exceedingly rapid. Nickel had been thrown down by the current as early as 1840, in the early part of which year a patent was issued in England to J. Shore for a method of plating with nickel. The subject received little or no attention until 1869, during August of which year Dr. Isaac Adams of Boston patented and introduced the double salts of nickel and ammonia for the purpose of nickel-plating, and nearly all the nickel-plating done at the present time is accomplished by the aid of these, the one usually employed being the double sulphate of nickel and ammonia.

Solutions of this salt, in varying strengths according to circumstances, are used generally in wood vats which have an internal protective coating of asphaltum. The current from two or three Bunsen or Grove cells is sufficient to deposit the metal from the solution, which should be kept neutral or slightly alkaline. A cast nickel slab is used as an anode. Nickel deposited in this way has about the hardness of cast iron, and takes a high polish, which it retains for a long time, owing to its resistance to the action of sulphur compounds. It does not oxidize readily, but is rapidly corroded by dilute acids, in which it is soluble. Its hardness renders it particularly durable.

The electro-deposition of iron upon the surface of copper electrotypes is a process of considerable technical value, as it greatly increases the durability of electrotypes so treated. Klein's solution for the electro-deposition of iron, which is one of the best, is made by precipitating a concentrated solution of ferrous sulphate with ammonium carbonate, and dissolving the washed precipitate with sulphuric acid, care being taken to avoid an excess of acid. The bath is to be used as concentrated as possible. With an iron anode and four weak cells a reguline deposit of metal is obtained.

For giving an iron surface to copper electrotypes M. Meidinger uses a solution of ferrous sulphate and ammonic chloride: the electrotype forms the cathode and an iron plate the anode. It is stated that these "steeled" electrotypes serve for producing from five thousand to fifteen thousand impressions.[1]

The character of the electro-deposited iron is of interest, as it is found when first deposited to have occluded about thirteen times its volume of

[1] Wagner's *Chemical Technology.*

hydrogen: it is nearly as hard as tempered steel and very brittle. It has a specific gravity of 8.139; it possesses a higher electrical conductivity than commercial iron; it does not warp or contract when heated, but slightly expands. Upon annealing it becomes malleable and about as soft as soft steel, and may be easily engraved. Plates from which banknotes and other engravings are printed are frequently duplicated, and may be multiplied indefinitely by copying them in electro-deposited iron.

A process the reverse of electro-deposition is sometimes employed for etching designs upon copper plates. The copper plate intended to be etched is uniformly coated with a protective film of etching-wax, and the design drawn or engraved through the wax film: the plate is then connected to the anode of a galvanic battery and immersed in a sulphate-of-copper solution. The circuit is completed by a copper cathode connected with the negative pole of the battery. The copper is deposited upon the cathode plate, while the liberated sulphuric acid and oxygen combine with and remove the copper upon the exposed portions of the design, which forms the anode. The etching may be carried to any desired depth, and when sufficiently deep the plate is mounted and used for printing.

Various forms of battery are used to meet special requirements. Bunsen's, Grove's, Smee's, and Wollaston's batteries have been the most popular forms for operations on a limited scale, but for extensive work the current from some of the various forms of dynamo-electric machines has largely supplanted the use of the more expensive galvanic battery.

PART VII.

DENTAL JURISPRUDENCE.

DENTAL JURISPRUDENCE.

By CHARLES G. GARRISON, M. D.

Scope of Article.

In this article we shall treat of the relation to the law in which the dentist stands by reason of his being a practitioner of dentistry. This is in reality a branch of medico-legal science or forensic medicine; for it is obvious that to the surgeon dentist, in all of his possible relations to the law, those same general principles will be applicable which apply to the general surgeon, the difference being rather in the limited class of operations and the nature of the services rendered than in the legal status of the operator or practitioner. But it is also equally true that there are certain questions of a medico-legal character which arise chiefly, if not exclusively, in dental practice, and which it will be found convenient and profitable to treat in their special connection with that subject; so that, both by reason of the relationship existing between dentistry and the practice of surgery, and because of the occurrence of these special cases, there arises a true jurisprudence for dentistry. It is of course impracticable in an article of this character to undertake a comprehensive treatise on this subject: that would require, not an article, but a volume; still less is it our object to make a work of reference for technical points of a legal nature, or to collect a list of cases at law upon this or that point of our general subject. Our object will therefore be to state general principles, with such applications as will render this article useful as a work of first reference to the practitioner of dentistry. There is no book on this special subject, so that we can refer the reader to no work as ampler authority. In a case of practical moment the proper course would be to take legal counsel with one having a special knowledge of medical jurisprudence.

Definition: Who may Practise Dentistry.

A dentist may be defined to be one whose occupation is the care of the teeth when sound, the treatment of their deformities and diseases when unsound, and the adaptation of substitutes for them when by age, accident, or disease they are lost.

In this definition is embraced the hygiene not only of the mouth, but also of the general system, of which the teeth are a sensitive index; it also includes the extraction of teeth and the preparation and adaptation of artificial ones, and the performing of filling and other operations upon the teeth themselves, and also upon their alveolar processes, and in some

cases upon the adjacent bone, although, strictly, these latter operations mark the limit which separates dentistry from oral surgery, a department of general surgery.

In the United States the spirit of the law favors the right of every man to practise any business or calling that he may elect, subject only to those State laws which are enacted for the protection of society from imposition or danger.

In the absence of any statute, therefore, limiting this common right to practise dentistry, any man may announce himself as a dentist and hold himself out as such to the public; but also by the same common law it is held that he practises at his peril, meaning that he is liable to actions at law for culpable ignorance. This being the doctrine of the law, it is evident that in the absence of statutory regulation no distinction is made between graduates of dental colleges and non-graduates, still less between graduates or practitioners representing different schools of practice.

It is of course otherwise if any State law or statute prescribes particular qualifications for the practice of the profession; for in this case he who undertakes to practise without having observed the prescribed regulations is doubly a wrong-doer, both as against the State and the public. But mere codes of ethics of dental societies impose no legal obligation: they are not, like statutes, of legislative enactment, and courts will take no official cognizance of them. The obligations which they may impose upon members of a professional society are conventional or moral, not legal, while over citizens at large they are entirely inoperative.

Many of the States and Territories have enacted statutes regulating the practice of dentistry; and it is a singular fact that while so many States have enacted such ample legislation on the subject of dentistry with the avowed object of affording protection to society from ignorant or unskilled practitioners of that art, the statute-books of these same States should in very many instances contain no similar or adequate regulations in regard to the practice of medicine; the logical deduction from which facts would be that the preservation of the teeth is of more importance than that of life itself. However flattering this may be to the dental practitioner, candor compels the suggestion that the true cause of the anomaly is to be found in the jealousy existing between the schools of medicine, any attempt to regulate the practice of medicine being opposed by one or the other pathy as amounting to a recognition of the exclusive claims of its rivals.

The various relations in which the practitioner of dentistry as such may stand with reference to the law all resolve themselves into three, which we may designate briefly as those of plaintiff, defendant, and witness. The first is when the dentist invokes the law in his behalf; the second, when the law is invoked against him; and the third, when as an expert he testifies at a trial in court or in some other proceeding. This classification exhausts all the possible relations in which the law applies to, or is applied to by, the dental practitioner; and this classification we shall follow in the arrangement of the matters of this article, taking up the subject in the order above indicated.

The Dentist as a Plaintiff.

A practitioner of dentistry may be said to be a plaintiff when he brings suit in a court to recover for his professional services or for injury to his professional character. The latter we dismiss from consideration here, for the reason that it pertains entirely to the domain of law, there being nothing in the law of libel and slander peculiar to dentistry.

We cannot, however, dismiss the question of suits for professional services without first presenting certain matters of practical moment. And at the threshold we meet a large mass of positive law bearing directly upon this right of a dentist to sue for his services—viz. the statutes concerning dentistry enacted by the several States and Territories. These enactments provide generally for the observance of certain prerequisites upon the part of the dental practitioner before he can lawfully either practise his profession or bring suits in courts of law to recover for his services as such; and penalties are in many cases affixed for failure to comply with these requirements. As this is intended to be a mine of reference for practitioners who may reside in all sections of the United States or who may contemplate a field of labor in any part of the land, we have made and placed at the end of this paper a compilation of these statutes, representing the most recent legislation upon this subject.

Now, prēmising that the practitioner has duly complied with the local or State laws in all their requirements, we may proceed with a brief consideration of the dentist as a plaintiff. The right of a qualified licensed dentist to recover for services rendered rests, as do all similar actions at law, upon a contract between the plaintiff and the defendant or party sued. It must not, however, be understood that a definite stipulation must be shown, as this—which in law is called an express contract—is very rarely entered into in professional engagements; for in the absence of an express contract the law raises an implied contract to the effect that the party at whose instance and request services are rendered will pay a reasonable price for them to the party who renders such services. When, however, an express contract has been entered into, it must be proved, and both parties must stand or fall by its provisions. Thus, if a dentist agree to do certain services for an agreed price, he can recover no more, even though it turn out that the actual service rendered was much greater than either party had expected. But in the absence of this express agreement the implied contract is just as binding. The dentist, then, when a plaintiff, must be prepared to show by proof as the basis of his action either an express bargain to do a specified service at a stipulated price, or he must show that certain services were rendered defendant at his request under such circumstances that a legal implication to pay a reasonable sum for them arises as a presumption of law. This proof will of course vary, conforming as it must to the facts of each case, nor will it be profitable in this place to pursue this subject farther, as it would lead us into the domains of law.

Mode of Making Charges for Services.

But a word will not be amiss on the mode in which charges for dental services are made. Every practitioner makes or should make an immediate memorandum or entry in some book of the work done or services rendered a patient.

This is his book of original entry, corresponding to the day-book of commercial transactions. To this original entry much importance attaches in law, for it is by this the plaintiff proves his claim, and it is of great practical importance that it should be a plain statement of the facts it is intended to record. Various methods are in use by dentists—some even copyrighted—wherein day-book and ledger are combined and various marks and signs substituted for plain and more extended language, a key being necessary for the use or interpretation of these patented systems. When suits are brought these mysterious methods of bookkeeping are viewed with disfavor by the courts and distrust by the juries, although they may be used as the basis of the plaintiff's testimony in substantiating his claim or for the purpose of refreshing his memory. Sometimes they are overruled and excluded as evidence, even when sworn to by the practitioner who is a witness in his own behalf, while in cases where, after the death of a practitioner, suits are brought by his representatives to recover for money due on the books of decedent, these hieroglyphics are summarily ruled out of court, and the possibility of collecting by law the amount due is hopelessly barred. In view of such a possibility it is recommended that a simple method of bookkeeping be adopted, the plainer the better.

Legal Liability for Services.

It may also be of practical benefit to remark while on this subject that dental services rendered to a married woman, either personally or to her family, must upon a general principle of law be charged to and collected of her husband, notwithstanding the fact that the wife may be the financially responsible party, unless the services are rendered in consideration of her express promise binding her separate estate for the payment thereof.

A further point to be noted in this connection is where, a patient being unable to pay for services about to be rendered him, a third party assumes the responsibility of their payment in case the patient makes default. In these cases such promises are worthless unless reduced to writing and signed by the responsible party looked to for payment. If, however, the responsible party agrees to pay for the services unconditionally, then the services should be charged to and collected of him, the patient being ignored in the financial transaction.

Amount of Fees.

The law sets no limitation on fees of dentists or other professional men, provided they be reasonable and bear a relation to the services rendered: within this rule a professional practitioner may use discretionary powers, charging more or less for his services according to his

own estimate of their value, subject to the single exception—viz. that a patient has a right to presume that similar charges will be made for similar services; that is, that the practitioner will adhere to his customary prices in former operations or services until some notification of an advance in price is given.

No one will pretend to assert that the services of all practitioners are of like value. There is a diversity of skill and talent. A professional man unusually eminent and with an established reputation based on long experience is publicly understood to expect larger fees than a more obscure practitioner for substantially the same services. Nor can any rule or principle of law be invoked to prevent the recovery of the larger fee charged, provided, in view of all the circumstances, it be a reasonable one.

Defences to Suits for Services.

Let us now look for a moment at the nature of the defence which may be offered to a suit for services such as we have been considering. The party sued may reply that the services for which pay is claimed were not rendered, or that he or she is not legally liable because of marriage or because they did not contract to pay. These and like defences rest on general legal principles in no wise peculiar to dental practice, and hence not to be considered here.

But, on the other hand, the defence, while admitting the contract and that certain services were rendered, may rely upon the fact or allegation that no benefit was realized to the patient, and upon this ground may seek to be released from payment. This is ordinarily not accepted by the court as any defence at all, and for the reasons stated heretofore. What the practitioner under the general implied contract above mentioned agrees is, that he will render certain services with a certain amount of skill and with due care: he in no sense becomes an insurer or guarantor of the result. This is based upon the uncertain part played by natural laws not under control of the parties. Nor does the ordinary contract impute to the practitioner the assumption of an extreme degree of skill, but only of a fair average knowledge of his craft. This being the nature of the legally implied contract, it is evident that it is no answer in law to say that no benefit accrued to the defendant, unless it be shown that the practitioner so lacked ordinary skill that his practice was a pretence and a fraud on the public. Of course if a special or express agreement existed by which a definite result was insured, or in which it was agreed that if there was no cure there should be no pay, in this case, as a general rule, the parties are held to the terms of their own undertaking, however foolish such bargain may have been.

This brings us to the consideration of the second attitude in which the dental practitioner may stand to the law—viz.:

The Dentist as a Defendant.—Compulsory Services.

Dental surgeons are so frequently the subjects of suits for malpractice that the question of liability is one of peculiar, as well as one of

personal and professional, interest. Not only are practitioners sued for alleged malpractice in the rendering of professional services, but suits against them are sometimes threatened, if not actually brought, for refusal to render services when requested. Thus, a dental surgeon who is called upon to perform a certain operation, it may be of extraction or what not, is threatened with certain legal consequences should he refuse to comply. Indeed, the existence of some such legal right of compulsion is a tenet firmly entrenched in the public mind. There is, however, no foundation in law for such an idea. A dental surgeon is not a common carrier. Indeed, the whole theory on which the relation of surgeon and patient rests under the civil law is that of gratuitous service growing out of personal confidence, which is fatal to the idea of compulsory attendance, as it is also, by the way, of compulsory payment. Fortunately, the modifications of the law have worked in the direction of enabling the professional man to recover payment for what services he renders, but not in the way of forcing him to render services when he may recover no pay, or where for any reason or for no reason he may see fit to decline.

If, however, he has once accepted a patient or undertaken a case, he must continue to perform the required services of his engagement unless dismissed, or until he shall have given such ample notice of an intention to withdraw that another attendant can be certainly procured. But at their inception all professional services are purely voluntary.

Suits which may be brought against practitioners of dentistry are either civil or criminal. The former are those in which the person sues for money damages for alleged personal injuries inflicted by the dentist; in the latter the State indicts the practitioner as a criminal for unlawful injury to human health or life or for violation of some positive penal statute. Of the last-named class are cases in which certain penalties are prescribed for practising dentistry without a license. In these cases the question is simply one of fact—viz. whether the statute has, as a fact, been violated—and the offence, if committed, is purely a technical one against society. With these cases we have nothing to do, as they come under general legal principles in no wise peculiar to dentistry.

Cases of criminal indictment against dentists for injury to health, and even for taking life itself, are of not unfrequent occurrence. It would serve no good purpose here to detail cases or to cite authorities, as the professional man who finds himself in so serious a position will always have recourse to a legal adviser, to whom the principles of law applicable to these cases are familiar and the details of practice known. What is intended here is simply to give some general ideas of the responsibilities assumed by the practitioner in the eye of the law when he approaches any case requiring surgical interference, and particularly in which the administration of an anæsthetic is indicated; for by far the greater number of these cases of criminal action for homicide arise in cases where death has resulted from the administration of an anæsthetic agent, such as chloroform. But, as the principles of law applicable to the dentist when arraigned in a criminal prosecution are the same as those involved in suits for damages against the practitioner of dentistry for personal injury, it will be convenient to consider them together.

Civil Suits for Damages against Dentists.

Civil suits for damages against dentists, while of less frequent occurrence, are still of sufficient importance to warrant our attention. These suits are generally brought upon the claim or allegation of patients that the practitioner has inflicted some injury on them, as that he fractured the jaw in extraction, or inflicted injury in some operation, or destroyed the health by permitting a tooth or other foreign substance to be swallowed by the patient, or by the administration of the anæsthetic; and the claim of the plaintiff is that the court award him pecuniary damages commensurate with his injuries.

Now, the way the courts look at these cases is this: The first inquiry is, Does the injury in point of fact exist? Is the claimant for damages really the recipient of any injury? The practical answer to this question involves an examination of the plaintiff with a view to detect whether the claim be not spurious or imaginary. And here each case must be its own guide, the general rule of law, however, being that the claimant must prove actual injury to the satisfaction of the jury. Supposing the fact to be established in the case that the plaintiff has suffered an injury, the next question is, Did he come by it at the hands of the defendant, the dentist or practitioner? This question also, being one of fact, must be proved by the party alleging it conformably to the general rules of evidence. If the facts be established that the plaintiff is injured and that such injury was received at the hands of the defendant, the legal questions then arise. In civil cases the question of law is whether the defendant is liable in damages; in criminal cases, whether he is guilty.

It would serve no good purpose to go into the history of trials of this character or to follow step by step the course of judicial opinion on this subject. Suffice it to say that the following statement of law may be taken as an established proposition.

Rule of Law Stated.

A dental practitioner possessing ordinary skill and using reasonable care is not liable for injuries to a patient which resulted not from negligence, but from causes which ordinary skill and care could not foresee or prevent. This will be found to be true equally in civil cases which sound in damages and in criminal suits for malpractice.

There are in this proposition two expressions upon which the legal force of the whole turns: "ordinary skill" and "negligence." Both are vital. If a man lack ordinary skill, if he be never so careful he is liable for malpractice; but, on the other hand, no matter how skilful he is, if he is negligent he is also liable. It is therefore important to know what constitutes ordinary skill and negligence in their legal acceptance.

Ordinary skill is that amount of professional knowledge, combined with practical dexterity, which in theory of law every practitioner should possess to entitle him to practise his art, and without which no one can practise without being held to strict account for the consequences.

The term is of course not a fixed one nor one easy of formulation; in fact, the courts do not attempt to lay down any rigid rules on the subject, but allow in each case the fact to go to the jury whether in that case the defendant was or was not possessed of ordinary skill. The term, therefore, while necessarily vague, is by no means trivial, inasmuch as the original basis of all professional responsibility rests in the implied promise of skill in the art practised.

For a professional man to lack ordinary skill is *de facto* a fraud upon his employers. The want of ordinary skill by one armed with a title and advertised as a practitioner is a wrong against the public, whose criticism is eluded and whose confidence is bespoken by the bare public announcement of a person as a dentist. Each citizen cannot take the time, even if he possessed the ability, to inquire into the individual proficiency of each applicant for professional favor; hence every practitioner is presumed to be furnished with that amount of skill which by virtue of his calling he is under moral and legal obligation to possess; in other words, "ordinary skill." The actual amount of skill may not be very great; it may and does vary widely among men in the same profession; but it must be sufficient to enable him without fraud or wrong to assume the responsibility of practising his calling; otherwise every professional act is tainted with fraud, and every injury at his hands is actionable and criminal. This doctrine, though apparently too refined, because it cannot be the subject of enforcement in the courts, is yet the original basis of the system of *licensing*, which is nothing more than an announcement through an established channel that the licentiate possesses ordinary skill.

A dentist, therefore, who does not possess ordinary skill is liable for malpractice without reference to whether he was negligent or not. Nor must it be inferred that the circumstance that a dentist is licensed establishes in any given case the fact that he possesses ordinary skill; that must be for the individual jury to determine from the evidence adduced before them.

The license is for the general information and protection of the public, not for the information of juries in legal proceedings or for the protection of professional characters when in courts of law.

"Ordinary Skill."

It is of course extremely difficult to determine with any degree of exactness what constitutes such a want of ordinary skill as will enable us to establish a general principle applicable to all cases in which deficiency of skill is alleged. Every case has its own complexion, each operation its own difficulties and surroundings; each patient has his or her idiosyncrasies and constitutional peculiarities; so that it is impossible to lay down in advance any standard of prerequisite skill the want of which would in that particular instance render the practitioner liable for malpractice. A practitioner is not to be blamed merely because he has encountered a state of things beyond his art to remedy or prevent. Even fatal cases are not necessary reflections upon the skill of the operator, but belong to the sphere of natural and unforeseen consequences.

"Want of skill," says Willcocks, "does not mean the want of the greatest possible professional talent or attainments, still less does it signify the having erred in opinion or mode of treatment, but the want of that general and ordinary knowledge of the profession which the law expects of every man who ventures to proclaim himself a member of it, or a total want of professional skill and knowledge in a particular operation which he has undertaken."

What is demanded, therefore, in every practitioner is simply that average amount of knowledge and skill necessary for the ordinary duties of his profession.

In a recent English case the court said: "To render a surgeon [and the same will apply to a dentist] liable, even civilly, for negligence or want of due skill, it is not enough that there has been a less degree of skill than some other professional man might have shown: there must have been a want of competent and ordinary skill, and to such a degree as to have led to the bad result."

When the allegation in a suit is that the dentist did not possess ordinary skill, the fact of his graduation at a regular dental college, and the fact of his having passed examinations, as for licensing, are competent in evidence, not as establishing the fact that he possesses skill, but as tending to disprove a material allegation of the plaintiff's case, long experience and universal custom having resulted in a canon of presumption that the possessor of a regular dental education has certain qualifications, one of which is ordinary skill.

Such, then, is that ordinary skill the lack of which is an important element in every civil case and criminal prosecution.

But, granting a practitioner has ordinary or even extraordinary skill, he is still liable for any injury which results from his carelessness or negligence. This brings us to speak of negligence as an element in suits against dentists.

Negligence.

Next to the obligation upon the dentist of possessing ordinary skill stands the duty of using it zealously in every case which he may have undertaken. We have seen that a dentist is not compelled to take any case which may offer itself, but, having once assumed the care of a patient or undertaken an operation, he is bound, both legally and morally, to use in all respects due diligence, the failure to do which constitutes negligence.

It is evident that negligence is as much a fraud upon his employer as want of ordinary skill, and for the same reason—viz. that the tacit assumption in all cases is not only that the person who holds himself out as a dentist possesses ordinary skill, but that if employed in any given case he will diligently and carefully apply his skill to the benefit of the patient. The law thus implies upon the part of the dentist assiduity as well as proficiency, and punishes negligence no less than want of skill. And, indeed, from the standpoint of the civil law and from that of the moral code, the man who, possessing skill, neglects to use it is more culpable than he who, though ignorant, honestly strives

to produce a cure. Equally in either case that confidence is violated upon which the implied contract rests.

We may take it, then, as an established rule of law that a dentist in the performance of his professional duties will be held liable for injuries resulting from want of diligence, care, or prudence, and this without reference to the amount of skill he may possess; the rule being the same in the criminal as in civil courts.

As to what constitutes due care or diligence in a given case it is impossible to say in advance, that matter practically being left, as other facts are, to the jury upon the evidence in the case. In some cases that can be mentioned the carelessness is so gross as to leave no question; as, for instance, where an operator, intending to extract a decayed tooth, extracts its sound neighbor. But in most cases that come before the courts the question of negligence or no negligence is a very close one, to be decided only after a full and impartial review of all the circumstances and difficulties of the case.

Rule in Certain Cases.

In suits of the character that we are now considering there have arisen and will arise questions of a purely legal nature closely involved in the relation of dentist and patient. Thus, if services rendered to one under legal age be made the basis of a suit for damages for malpractice, can it be maintained, the infant being unable in law to enter into the contract? This and all similar questions arising out of the purely legal relation we shall not consider here. But for the purpose of affording practical information we shall simply state that a dentist may be sued civilly for damages for malpractice to an infant or to a person who is an inmate of a public hospital of which the defendant is an attendant, these suits proceeding on the ground, not of breach of contract, for none existed, but of wrong done to a citizen for which the policy of law permits that citizen to recover private damages, as well for reimbursement for the injury received as for punishment to prevent repetition.

Whether the husband and wife should join in a suit for injury sustained by the wife is a question now regulated almost solely by the statute law of each jurisdiction.

Contributory Negligence.

While the law thus holds the dentist liable for all injury inflicted by him through lack of ordinary skill or actual negligence, it is always with one reservation—viz. that there shall have been no contributory negligence on the part of the patient. Of this we shall now speak. The doctrine of contributory negligence is a purely legal proposition, but, as it proceeds on reasonable and fair grounds, and as its comprehension is essential to an understanding of the factors which make up personal responsibility in matters of malpractice, we shall here briefly state what that doctrine is.

A broad legal statement of this rule would be that a person who has

received an injury by the ignorance or negligence of another cannot recover damages therefor if his own negligence actually aided in occasioning the injury. The legal refinements, distinctions, and niceties which have grown up around this rule would fill volumes, but for our purpose the above statement of it will suffice. In plain, untechnical language, and with reference to our subject, we can say that if a dentist treats a case unwisely and carelessly, and the patient also neglects or refuses to take due care of himself, so that injuries are sustained partly attributable to the negligence of the dentist and partly to that of the patient, no suit for damages can be successfully maintained, because of the rule of law in question.

Thus, to illustrate: If a patient be instructed by his dentist to insert in a dental cavity a piece of cotton saturated with carbolic acid of undue strength, and to do this night and morning, leaving it there ten minutes each time, and the patient should repeat it oftener than ordered and leave it for a longer period, so that sloughing of the cheek should occur, no damages would be recoverable, because the frequency and duration of the application (which were a negligence on plaintiff's part) were approximately as much a cause as the original undue strength of the solution.

Not to consider here the legal reasoning in support of this doctrine, let us direct attention for a moment to that view of the case which will occur to the professional mind. The services which are rendered by dental practitioners to patients consist in services rendered to rational, volitional beings, who cannot, in fact or in law, be regarded as simply *objective* inanimate substances upon which an act is to be practised; so that both by contract and by reason the patient has not alone the objective duty of quiescence during an operation or of acquiescence toward the professional adviser, but also the further and more important subjective duty of co-operation. By becoming a patient he does not relinquish his hold on Nature's first law nor divest himself of his rational character. Obey he should primarily, but he is also required to exercise his reason in such manner as to further what is being done for him by his professional attendant. To that extent (by a paradox) the patient becomes the special agent of the dentist: the patient accepts in trust his own well-being, and upon his faithful discharge of this trust rests his right to call in question the principal for whom he acts. This relation should never be lost sight of, for it constitutes a shifting trust which in cases of alleged dereliction of duty will decide whether the claimant can or cannot call his attendant to an account. If a patient can truly say to his dentist, "I trusted you, and faithfully obeyed the counter-trust you reposed in me," then he is in a position to claim damages for any malpractice. But if the surgeon can say to the patient, "I undertook your case, and trusted you to carry out and do all that you should to help yourself, and the injury you received is partly owing to your breach of this trust," then that plaintiff has, as we say, "No one but himself to blame."

The importance of the understanding and application of this doctrine in damage cases can scarcely be overestimated. In probably the majority of cases of alleged malpractice, could the fact be made to appear, it

would be found that deviations and departures of the patient from the strict line of good sense and common duty has been the starting-point of a series of unfortunate mishaps for which the blame is afterward thrown on the professional attendant or operator. For the successful treatment of any case it is of the first importance that a patient should submit himself to the guidance of his adviser: that he should also neglect nothing that would aid in his recovery is of almost equal importance. If he will not do the one or neglects to do the other, the burden of responsibility is clearly shifted from the adviser to the patient, and the former both morally and legally ceases to be accountable for the ulterior consequences of a treatment which, though it was undertaken by him, has been interfered with or has not received proper co-operation in the course of its execution.

Such is the doctrine of contributory negligence as applied to our subject, and the reasoning by which it is sustained.

Suits for Injuries from Anæsthetics.

The administration of anæsthetics, with its results and accidents, has given rise to the greatest number as well as the most serious cases of dental malpractice. Yet the principles of legal reasoning and relations which we have been considering are identically the same in reference to these cases as in those of mere mechanical injury. The only difference is in the application to the facts and essential features of each case. The same questions of ordinary skill and negligence arise, and are to be met or answered by reference to the rules heretofore laid down. Thus, the dental operator who presumes to employ a death-dealing drug must possess a fair working knowledge of it in all its phases. The slightest falling below this standard marks him as one who used a fatal agent without being possessed of ordinary knowledge or skill.

It will be seen at once that a wide field is here marked out. Many questions are to be considered by the operator; as, Does the operation demand anæsthesia? Does it require prolonged anæsthesia, or will the nitrous oxide suffice? What is the condition of the patient? Has he any signs of faulty circulation? Is he in condition for the administration? These and as many other questions have to be met and decided in the light of modern medical knowledge before the operator dare pass to the consideration of what anæsthetic to employ or to the practical details of its employment, with the numerous niceties therein involved; each of which, if unobserved, may be followed by fatal results, but the knowledge and use of which constitute but the ordinary skill required by the law of him who resorts to their use.

The distinction previously pointed out is significant here—viz. that if an operator does not possess ordinary skill he is responsible, no matter how careful or zealous he may be; thus, if one unacquainted with the true mode of administering chloroform, having mistaken and ignorant views in regard to it, should undertake its administration and fatal results ensue, the full force of legal presumption would be against him without reference to proof of care in its administration; whereas with the educated physician of experience the presumption is in favor of the

correctness of his method of using the anæsthetic, and he who charges the malpractice is compelled to prove the negligence.

We have seen that the rule of law which demands of the operator ordinary skill and the absence of negligence is the same in cases of death ensuing the administration of anæsthetics as in cases of less serious injuries. While this is true, still the grave nature of a homicidal charge naturally inclines the court to draw the line of responsibility more strictly in cases where human life is the possible issue. Hence in the case of the administration of so potent an agent as any one of the anæsthetics the skill demanded is held to include all known rules which the experience or wisdom of the profession has discovered and promulgated. To omit any known precaution in the administration of an anæsthetic will be taken as an indication either of the lack of ordinary skill or as the lack of proper caution. Thus, should the practitioner attempt an operation alone, having no experienced administrator to look after the patient's varying condition of pulse and respiration during the operation, it would, upon the occurrence of a fatal result, be imputed to him as criminal negligence. Similarly, the administration of the anæsthetic to a patient in a position other than the recumbent one would likewise be deemed *primâ facie* to indicate ignorance or carelessness, the knowledge of the complementary action of the intercostal muscles and the diaphragm, and the liability of the former to become paralyzed, so as to demand free play to the latter, being now part of the common stock of professional knowledge required of the practitioner. The same may be said of the failure to loosen the clothing at the throat and waist. In fine, the law demands that before one presumes to deal with an agent dangerous to life he must make himself master of all current knowledge bearing on the subject, and be responsible to the rule that a failure either to know or to apply this knowledge will carry with it the burden of guilt.

Rape under Anæsthetics.

In addition to suits against dentists for malpractice and for injuries or fatal consequences resulting from the administration of anæsthetics, indictments for rape committed by dentists upon patients who were at the time under the influence of the anæsthetic have been brought, and the defendant found guilty and sentenced therefor. The great importance of this branch of our subject, the ignominious nature of the charge, and the extremely questionable nature of the evidence on which such cases must and do rest, warrant our closest attention. That a professional man should in the pursuit of his calling be exposed to charges of this kind is in itself a grave matter; but if the charge is to be based upon and sustained by evidence which may be remembrance or may be pure hallucination, the position becomes appalling.

The leading case in this country is that of Dr. B——, a highly respectable dentist of Philadelphia, a widower—the patient a young lady of unimpeachable character, who was engaged to be married, and who, on the occasion in question, was accompanied to the house of Dr. B—— by her betrothed. She arrived at the dentist's residence at

about ten o'clock in the morning, and after a few moments spent in awaiting the departure of two other lady patients she was ushered into the doctor's office. From the interest and importance of the case we will let her continue the narrative in her own words, as given at the trial:

"I went into the office; took off my bonnet, and Dr. B—— went to the washstand to wash his hands; he asked me after the family; I took a seat on the operating-chair; in a few minutes Dr. B—— told me one of the men wanted to speak to him, and he gave me a book to read and left the room; did not say what man; I supposed there were men there; he has a room in which the teeth are made; I believed those to be the men. Dr. B——'s family were out of town at that time; he said so, and the door was opened, and there was no furniture in the front room. I don't know how long Dr. B—— was absent; when he came back I was sitting in the operating-chair; he went to the instrument-case and began with my tooth; the tooth was on the left side; he commenced operating on the tooth before he gave me ether; the operation was very painful; he said he would either put something in to destroy the nerve or give me ether, leaving the choice to me; I told him I'd prefer taking ether; I didn't learn what he proposed putting into the tooth; he gave me the ether on a small napkin folded up. I felt very dizzy at first; I was cold and felt very numb; it increased upon me; I did not lose my consciousness of what I was doing; I continued to breathe the ether; my eyes were closed; I closed them voluntarily; I did not try to open them for some time after. After he gave me the ether he did not, as I remember, operate on my tooth; he felt my pulse several times, put his hand on my arm under my sleeve, up my arm; I had a loose sleeve; he did it once; he put his hand on my breast under my dress, on the bosom; he put his hand on my person, under my dress; I have a distinct memory of that. I was not able to make any resistance or outcry. He went round before me and raised my clothes; I am perfectly distinct in my memory of that. I did not try to cry out; do not know if I was able. After he had raised my clothes my feet were crossed, and he raised them and put one on each side of the stool; he then put his arm around me under my clothes; he drew me down to the edge of the chair. I do not know what he did after that till I felt pain; he did enter my person; it was then that I felt the pain; I was not able to cry out or resist; I did not try; I don't know what was his position; my eyes were closed; I have no doubt that he did enter my person, and did give me pain. All this time I was conscious of everything that was going on. After this he left me and crossed the room to the washstand; I heard him pour out water into the basin; after he had been to the washstand and returned I opened my eyes and saw my clothes up; he did not see me; I have a clear recollection of seeing my clothes up; I closed my eyes immediately. He put down my clothes, and in a few minutes he was at the side of the chair, and lifted me up into the seat; I was just to the edge of the seat; it was a large dentist-chair. In a few minutes he told me he'd have to take the tooth out; that was the first remark he made, except the first when he asked me if I was getting sleepy. At the time he entered my person I did not feel his person against me; pain I distinctly felt. When he spoke about taking out the tooth, I asked him why; he said they were both decayed, and he could not save them both. I told him I was afraid it would pain me, and he said he would not let it; he then gave me more ether, and extracted the

tooth. I was on the left side; when he extracted the tooth it was painful; I screamed then; he then assisted me to rise, and led me to the rocking-chair; I felt a little dizzy when he led me to the rocking-chair; he then went out of the room, and in a few minutes came up with a lady; I have not seen her since; he asked me if I would be introduced to her; I believe I said no; he did not introduce me then. I heard him tell the lady he'd always been our dentist, and that we never had been to any other; he said my teeth were very good; he said I had taken ether when the tooth was extracted; I think she said something about hearing me scream; he said Yes, ether had not much effect on me; I was either nervous or for some cause; in a little while I got up, and he introduced me to the lady; I think it was Mrs. P——. I made several remarks, but I don't know what they were; I then put on my bonnet, and Dr. B—— followed me down stairs; the lady was left up stairs; he came to the door, and I wanted to stop an omnibus; he asked me how far I was going, and I told him to Third street and Lombard; he told me I had better walk; he said he thought that I had some of the ether in me, and the walking would do me good; I walked down Walnut to Sixth, and did not get into an omnibus; I did not reproach Dr. B—— at the house; I was afraid. I stopped in C——'s ice-cream saloon at Sixth below Prune; I got ice cream; I went then along Sixth street to Spruce, and down to Third and Lombard streets. I was going to see a young woman that sent for me; I did see her; don't recollect how long I was there; when I left I came up to Mr. T——'s, at Chestnut street near Fifth; I was very intimate with Mr. and Mrs. T——; I met Mr. M—— on the way up, near Sixth and Chestnut streets; he joined me and spoke to me; did not accompany me to Mr. T——'s; did not meet any but those I have named; I reached Mrs. T——'s at one o'clock; they had not been to dinner; I first mentioned to Mrs. T—— what had occurred at Dr. B——'s the same day after tea; that afternoon I was taken unwell; it was the usual time. The door of the dentistry-room at Dr. B——'s was shut; there are two doors in the room; the one leading to the entry-door was closed; Dr. B—— said that he closed the door because the smell of ether would go over the house; the door was shut before he gave me the ether; the chair is one that leans backward."

The result of this case was that Dr. B—— was found guilty of rape and sentenced to four years and six months' imprisonment.

Value of Evidence of Prosecutrix.

In this case the indictment was sustained solely upon the testimony of the young lady herself, the gravamen of whose testimony was that during the whole period occupied by the assault she was too profoundly under the influence of the anæsthetic to either resist or make any outcry, but remained utterly passive. Obviously, then, her testimony upon this point is derived solely from her remembrance of the impressions she retained of what occurred while in the condition of etherization, which she admits had taken from her all voluntary action.

Acceptance of this kind of testimony implies that in the opinion of the court it fulfilled the essential condition of legal evidence.

Under every rule of evidence the testimony of any witness is the remembrance of that witness of a material fact observed by him or her

while possessed of perceptive faculties and in a state of rational consciousness. But even this definition is not sufficiently broad to include the testimony of the witness in this leading case. For observe that as prosecutrix complaining of an assault the gravamen of her case was the admission that she was so far under the toxic influence of the anæsthetic as to be and remain utterly passive under the alleged assault. According to her statement, not only did she offer no voluntary resistance, but her admission carries with it the assertion that the administration of the agent had been carried to that point where the muscular system fails to respond in the way of reflex action to exciting causes. This is the witness's own statement necessary to her case, and must be considered in judging of her fitness as a witness. So the question presented is this: What is the condition of the perceptive and mental faculties of an etherized person when the power of reflex action has succumbed to the anæsthetic? This is not a difficult question for science to answer.

The sequence of the phenomena of anæsthesia is quite constant. The successive stages are laid down by writers with substantial agreement.

Dr. B. W. Richardson says there are four degrees or stages:

The first stage is that in which consciousness is not lost. There is resistance and a desire for air.

In the second stage consciousnesses is lost, but surgical operations are impossible, the patient struggling and screaming without provocation.

The third stage is that of complete unconsciousness and when all rigidity is lost; this is the stage that permits of the operation.

The fourth is the dangerous stage, when the agent has been carried too far.

According to another medical writer, Prof. Weisse, the progressive steps in the production of anæsthesia depend upon poisoning the blood-supply, and the consequent paralysis of the nervous system, and are as follows:

First, paralysis of the peripheral sensory nerve-fibres.

Second, paralysis of the cerebral hemispheres, by which intellectuation is impaired and consciousness gradually lost.

Third, paralysis of the cerebellum, by which muscular co-ordination is arrested.

Fourth, paralysis of the cord, which leads to the relaxation of the voluntary muscles.

Fifth, paralysis of the medulla oblongata, which presides over the heart and lungs, this last being the fatal stage.

These stages will be recalled by any one who has studied or observed exhibitions of anæsthesia. Who has not noted the restlessness in the first stage, and the violence of the second when reason has gone and consciousness is fast going, and how the violence is always coherent with imaginary mental hallucinations? Upon the subsidence of these quasi-mental manifestations the talking and screaming cease and the voluntary bodily movements subside; but even in this stage, which is the one usually chosen for minor surgical operations, including extraction, reflex action is not suspended: especially is this true of reflex sensory action. How invariably do the hands go up toward the mouth to grapple aimlessly with those of the operator! The next stage is that

of profound unconsciousness, almost of coma, with suspension of all bodily movement and a departure of reflex response.

It was in this last stage that the witness, by her testimony, locates herself at the time of the assault she testifies to. At any previous stage she would have made reflex resistance. If she was utterly passive and quiescent then, she had reached this the first point at which reflex action is suspended.

But we know that reflex action remains to the patient long after the senses are confused, when ideation has become hallucination, and even after consciousness has vanished. Preceding even any of these mental states the mind has become the seat and scene of the wildest and most unsubstantial fancies—to vagaries so wild and ludicrous that no one thinks of giving credence to what a patient fancies was happening while under the anæsthetic. It may be safely affirmed that when the patient has been carried to that stage of anæsthesia where the reflex motor function is null, there perception, memory, reason, consciousness, have all long since abdicated their thrones.

But in the leading case the witness, who was a virgin, said she *felt* the pain of this first intercourse, yet it *excited no reflex action*—no movement, no resistance, no sound; she remained passive utterly. What must have been, then, the state of the perceptive or mental faculties when this stage of anæsthesia had been reached?

This view of the subject is entirely apart from that other equally suggestive one—viz. the known tendency of the anæsthetic to excite erotic delusions. The history of anæsthesia abounds with evidence and cases of the fact. Particularly would this be the case if there were any predisposing causes which controlled or directed the general tendency to hallucination in that particular direction. Any state of affairs of a physical or psychic nature, which either increased the flow of blood to the reproductive organs or which from mental or emotional causes established a tendency in that direction, would serve to guide and give shape to the delusions and hallucinations of the unconscious subject. Now, the witness in the leading case was under both of these causes. The evidence is that she was about to marry, and had been accompanied to the dental office by her fiancé, who left her, as it were, just as she took her seat in the operating-chair: naturally, then, he and the approaching marriage were uppermost in her mind, and would be sufficient to give that slightly tangible guide which is all that anæsthesia requires to turn the rudderless mind toward a subject which afterward might take any of those distorted shapes that dreams are made of.

But the evidence tells us the witness was also at the menstrual period —in fact, that her flow came on naturally the same day at regular time. At the time, then, that she took the anæsthetic she was just at the period of greatest uterine congestion and vascularity which precedes the menstrual flow—the very condition of all others to invite the anæsthetic delusion in that direction—a condition in which many women, without anæsthesia to account for it, are hysterical and subject to morbid fancies.

Here we have, then, every element needed to excite the known effect of a toxic agent, and have the patient's own statement to assure ourselves that she was fully under its power. In the face of these con-

siderations the acceptance of the patient as a witness in her own behalf seems monstrous. I have dwelt at length on this case because it is the leading one on a subject which in the domain of dental jurisprudence is the most important. There is no disaster which can befall a professional man so great as this—none under the ruling in this case against which he is so powerless. Of all the possible crimes that can be brought under our consideration, what one begins to equal this? Certainly not homicide, that standard by which other crimes can be graded. Dentists have had the misfortune to have their patients pass from the sleep of anæsthesia to that of death. But in these cases tangible ocular examination of the condition of the heart and kidneys could be made—testimony reasonable and lawful could be brought to show that death resulted inevitably from conditions which greatly, if not wholly, exonerated the operator. But in a charge of rape, where the sole evidence is the uncorroborated recital of the patient of what her memory held when she came out of profound unconsciousness of anæsthesia, what rebuttal can there be? What can be said? Once found guilty, on no matter what evidence, of this crime, what more remains? What would wealth, professional attainments, learning, business success, be worth with this stigma as their climax?

From what has been said it is evident that no dental practitioner should administer anæsthetics to a female patient excepting in the presence of an attendant or other witness. The practical value of this admonition cannot be overrated. There have been cases of attempted blackmail in these cases which serve to emphasize the rule, but the chief necessity arises from the circumstance that any woman under anæsthesia may honestly imagine herself to have been the victim of liberties or assaults, such hallucinations arising, as we have seen, from the peculiar relation between anæsthesia and the erotic feelings. In a case which occurred in Canada a witness testified that his wife on recovering from anæsthesia believed herself to have been thus victimized, notwithstanding the fact that he, her husband, had been present throughout the whole sitting. This case is reported in the *Boston Medical and Surgical Journal*, for Nov., 1858. For many other cases of similar import the reader is referred to Dr. J. F. B. Flagg's work on anæsthetics (Philadelphia, 1851) and to Wharton and Stillé, vol. ii. part i. p. 248 *et seq.*

Of the practical value of the suggestion above given there can be no question. Its neglect may to any practitioner bring untoward consequences which may render sombre his whole professional career.

Judgments in Suits against Dentists.

The results of suits for malpractice when the determination is against the dentist follow ordinary rules of law and practice. In civil suits the judgment is for the amount of damages found by the jury. The measure of those damages, as well as all matters pertaining to new trials for excessive damages or other legal questions, must be omitted here.

In criminal cases the sentence in cases of malpractice is, as a rule, regulated by statute, and is generally a fine; sometimes in cases of gross

ignorance or of a fraudulent or malicious nature a term of imprisonment is inflicted.

If manslaughter is charged and found by the verdict, the penalty follows the common law or the State law on the subject.

The Dentist as an Expert.

A practitioner of dentistry may appear and testify in a court of law in one of two characters: that is, either as a witness to relevant facts within his observation, or as an expert. In the former character he does not differ from other witnesses. To him the same rules apply as to any other person who, having seen or known some fact, is called to testify to it in the course of legal proceedings. In such cases the witness, as the word implies, knows something by having seen it, and his duty is to tell just what he knows or has seen, subject to the ordinary legal rules which regulate the production of all testimony.

In the other character—namely, as an expert—the dentist stands in the same category with medical and other experts. The difference is not of kind, but simply of the class of facts.

An expert in any department is one who in the art, science, or business in question has gained knowledge and experience by practice or observation therein. Mere theoretical education is not required, nor is it always sufficient to constitute one an expert. The term carries with it in legal circles an idea of knowledge acquired by practical acquaintance with the subject, so that a good general definition of a dental expert would be, one who has gained knowledge of the dental art and science in the course of his business pertaining thereto.

An expert is a witness, but, unlike all other witnesses, he is not called because he witnessed or observed or can testify to any of the ordinary facts relevant to the issue in the case. The expert is summoned to aid court and jury in coming to a correct understanding of the facts of the case by telling them what the meaning and significance of those facts are to one peculiarly used and skilled in their interpretation. Thus, a man dies of organic heart disease during anæsthesia by chloroform: an expert is summoned, not to testify that he saw that particular man die of heart disease, but to tell how any man with that species of organic trouble would be liable to be affected by the inhalation of chloroform.

It has been said, and is generally accredited, that the distinction between experts and other witnesses is that, whereas all others testify to *facts*, the expert alone gives *opinions*. To this attempted distinction, although it has the weight of judicial dictum, I cannot subscribe. Not only, as it appears to me, is the distinction a fictitious one, but also a mischievous one, in that it breaks the unity of the rule that all testimony should be as to facts, and leads to loose and unreliable opinionating.

Profoundly considered, what the expert is summoned to testify to is the condition of scientific or technical thought upon the question in hand: this condition of science is a substantive fact; if it were mere hypothesis or guesswork, why throw it into the jury-box? Thus, a question of medical science is necessary to the determination of a case;

the twelve men know not how to regard it: what they need to know is, What does the science of medicine have to tell us about this? A medical expert is then called—not for his lone personal opinion, but as an exponent of his science—to state what the craft for which he stands has to say upon a matter peculiarly within its domain. The difficulty of exactness makes this utterance too often a mere opinion. But, nevertheless, what the law requires is the fact as to the state of scientific thought upon the question in hand: the reason of its admissibility is that it is a relevant *fact*, and the expert's deliverance gains acceptance upon this ground. If it turn out to be an *opinion*, and not a *fact*, that is due to the frailty of human knowledge, and should be charged to it, and not to a loose jurisprudence which receives opinions as such, and demands nothing higher.

This distinction, properly understood, would not only simplify the legal rules of testimony, but would greatly strengthen and dignify the position of the expert, and save him from many of those fool-traps into which he stumbles. Much loose and confusing evidence is produced by asking for the witness's opinion which would be shut out or pruned down by demanding of him an expression of what light or knowledge his art and science have to throw on the subject. Often one member of a craft entertains views and opinions different from the whole body; surely the expert should give the accepted view of the whole, rather than the erratic opinions of the one, even though he happened to be that one.

It will not be proper here to go into the question of expertism, either in its legal or medical aspects. Any of the many publications upon that special branch can be consulted for full information. We shall content ourselves by giving some practical information and suggestions upon experts, and by calling attention to the only department of expertism peculiar to dentistry—viz. of identification by means of the mouth.

Knowledge; Practice; Rules.

Before a witness can be examined as an expert his competency as such must first be shown. The question is whether or not he possesses the necessary qualifications to render him legally able to testify in the character of an expert. This is for the court to decide as a preliminary matter. We have seen, in a general way, what those qualifications are—namely, that he has acquired the peculiar knowledge and acquaintance with the subject which come from practical experience. In order to determine in any given case whether the person who is presented as an expert is competent, the court will first cause him to be examined on his special opportunities for acquiring the necessary familiarity with it; how long he has engaged in or followed it; and other questions may be put tending to show whether he is properly qualified. The court does not attempt to inquire into or pass upon the extent or accuracy of his knowledge, but only whether his relation to the art or science to which the question in hand pertains has been such as to give him the character of an expert therein.

Limited to dentistry, the preliminary examination would be satisfied

by proof that the witness had received an education in dentistry and was or had been a practitioner. We may say, "was or had been," for while a practical knowledge is required, it need not be that the expert is still a practitioner: the knowledge remains after the expert has ceased to practise the art. But knowledge acquired by mere reading or study, without practice or experiment, mere book-lore, does not constitute a man an expert. Books themselves are not admitted in evidence, nor are their contents to be stated under the color of expert testimony. It is only when the suggestions of the books have been incorporated into the working art that their results can figure as the evidence of an expert.

There is no strict test for the settlement of this question: guided by the general rules above indicated, it is left largely to the discretion of the court.

A professional man, if called to testify to any ordinary facts within his knowledge, cannot refuse to attend. Whether or not he can refuse to attend as an expert to give testimony which derives its value and importance from his special skill and knowledge until he has been paid or tendered a special compensation, is one of the vexed and unsettled questions of law in the United States. The rule in England favors the giving of extra compensation as a necessary condition precedent to compulsory expert testimony.

In this country two views are maintained—one favoring the payment of extra compensation, and laid down in the cases of Buchanan *v.* The State, 59 Indiana, p. 1; In the Matter of Roelker, 1 Sprague, 276, in the U. S. District Court for the District of Massachusetts; and also in United States *v.* Howe, in U. S. District Court for the Western District of Arkansas, 12 *Central Law Journal*, 193. Another class of cases denies the right of extra compensation: Ex parte Dement, 53 Alabama, 389; Summer *v.* State, 5 Texas Court of Appeals, 374.

That this question should thus still be an open one is one of the many reasons which point to the necessity of appropriate legislation covering the whole question of expert testimony.

Certain States have already passed statutes upon this subject—viz. Iowa, North Carolina, Rhode Island, and Indiana. In the first three an extra compensation is allowed, while in Indiana it is expressly denied.

In this unsettled condition it would be unsafe for an expert witness to refuse to testify without compensation in any State where no statute covers the question, as the power of the court to commit for contempt is practically unlimited and not to be legally defied.

There is a current notion that any information a professional man receives in the line of his profession is a privileged communication which he cannot be compelled to divulge upon the witness-stand. This, however, is a rule of law which refers to attorney and client only. As to the medical or dental practitioner, it has no force, excepting always cases in which statutory provision has been made to cover the point.

Subject, then, to these general rules as to competency, the dental practitioner may be called upon to testify as to any matter within his pro-

fessional ken. When upon the stand he is, so to speak, turned into a talking encyclopædia of dentistry: questions upon every possible and impossible phase of his art may be put to him, some full of meaning, others vague, and many meaningless, the attorney who puts them, having superficially crammed for the examination, not always making sense. In addition to this running fire, hypothetical questions may be submitted to the expert. A hypothetical question, technically considered as a means of eliciting expert testimony, is a question which is framed upon either the admitted facts in a case or upon facts testified to and assumed in the question to be true. The object is to obtain the opinion of science upon the very facts of the case, but, as an expert is not permitted to draw inferences or conclusions of fact from the evidence, a parallel case is imagined and framed into a question, which, being answered, is retranslated into the terms and facts of the actual case. How counsel may frame these hypothetical questions—whether upon all the evidence or upon certain facts assumed to be proven; whether they may contain facts not shown to exist; how they may be made use of in cross-examination—are, together with a mass of kindred knowledge, all matters which are so exclusively within the domain of the jurist that they have no place here. The general rule is that the expert must answer all questions which have run the gauntlet of the objections of counsel and court. If for any reason the expert should feel that the question is an improper or an impossible one to answer, he may appeal to the court, whose duty it is to pass upon all questions, and upon whose rulings the witnesses, experts and others, must rely. With the management and outcome of a cause the expert should have nothing to do. An expert who is also an advocate cuckolds his science.

(For all further rules and practical suggestions as to the law, practice, and compensation of experts no better work can be consulted than *Expert Testimony*, by Henry Wade Rogers, St. Louis, 1883.)

Identification by Teeth.

We have alluded to identification by means of the teeth as the one department of expertism peculiar to dental jurisprudence. As a matter of importance this can scarcely be overrated. The universal defects in all other modes of identification, combined with the absolute certainty of the dental tests, should give it a just prominence. For, strange as the assertion may sound, nothing is more difficult than absolute identification. Even if the person is living it is hazardous. In cases where, though dead, no part of the body is missing or destroyed, it is often impossible to certainly identify the remains, while in cases where (as usually in premeditated crimes and in many casualties) mutilation has occurred, it may be safely said that no other test than that offered by dental jurisprudence is worth speaking of.

If the professional mind is once directed to this subject, wide details and particulars of dental work will at once occur as means of identification—the absence or presence of teeth; the condition of the alveolar processes; the presence of artificial teeth, fillings, or mechanical contrivances; the arrangement of teeth, state of decay, and many other pecu-

liarities. When to these we add the records, diagrams, and moulds used in modern dentistry, we present means of identification such as nothing else can afford.

That this is not fanciful or of an impracticable character will appear from a brief résumé of actual cases in which jurisprudence until it called dentistry to its aid was powerless to proceed in its investigation toward fact.

One of the most remarkable cases in the annals of criminal jurisprudence is the so-called Webster-Parkman trial which occurred in Massachusetts. On Nov. 24, 1849, Dr. George Parkman, a wealthy and well-known resident of Boston, suddenly disappeared. He had been last seen at the medical college of Harvard University in the company of the professor of chemistry, Dr. John W. Webster. A week after this disappearance portions of human remains were found in a vault in Dr. Webster's laboratory; other parts were found in a tea-chest, while in a furnace there were also found pieces of human bones. Among the ashes about one hundred and seventy-four grains of gold were discovered; also a human tooth, with a cavity in it once filled by a dental operation; three blocks of mineral teeth with rivets, but without the gold plate, and a great many fragments of bone belonging to the skull and lower jaw. The bones and teeth appeared to have been exposed to intense heat.

Under ordinary medical experts identification of these mutilated remains with that degree of certainty required by criminal law was impracticable. One Dr. Keep, who had for twenty years been Dr. Parkman's dentist, was called. He examined the mineral teeth and pronounced them his work, which he had done for the missing doctor three years before. He produced the mould of Dr. Parkman's lower jaw which he had taken, and it was found that the fragments of bone fitted exactly, making a jaw very peculiar in form and presenting certain distinctive characteristics.

In his testimony Dr. Keep not only identified the burned and mutilated jaw and teeth as those of Dr. Parkman in a manner which amounted to a demonstration, but also, from the melting and chemical effects produced, was enabled to say what had been the means employed to produce the partial destruction. The remains thus being identified, other evidence pointed so conclusively to Professor Webster as the murderer that on the eleventh day of the trial a verdict of guilty was reached by the jury. Dr. Webster eventually confessed his crime. His confession in a remarkable degree verified the particulars given by the dental expert.

Goss-Udderzook Tragedy.

But the most remarkable case in dental literature is the Goss-Udderzook case, which occurred in Maryland and Pennsylvania early in 1872. The particulars, in so far as they are necessary to a comprehension of the dental phase of the case, are here given in full:

On Feb. 3, 1872, a Baltimore newspaper stated that W. S. Goss, residing 314 N. Eutaw street, had been burned to death in a cottage the previ-

ous night. This house was several miles out of the city, and the fire was supposed to have been caused by an explosion of chemicals, with which Goss was experimenting in making a substitute for india-rubber. The house was entirely consumed. The remains of a human body were drawn out of the building, the lower limbs destroyed and the features so burned or charred as to be beyond recognition. From the shape of the chest, neck, and head the corpse was identified as that of W. S. Goss. Indeed, who else could any one suspect it to be? So the coroner held an inquest which rendered the verdict "that W. S. Goss came to his death by the explosion of an oil lamp."

The body was taken to Baltimore, and after solemn funeral services removed to Baltimore Cemetery. While it lay at Eutaw street the widow had no question as to the fact that the remains were those of her husband. She knew the contour of the neck, head, and breast. Some ten or more witnesses testified to their belief in the same identity, regarding the recognition of the body as not difficult or doubtful.

In May, 1871, W. S. Goss had seemed to be seized with a sudden mania for insuring his life. He had insurance to the amount of $25,000, payable to his wife. His last policy was dated eight days prior to his "cremation." The stories of William E. Udderzook and A. C. Goss, brother-in-law and brother of W. S. Goss, conveyed the impression that "they knew too much," and led the insurance companies at once to inquire into the facts. While all disclosures tended to strengthen the suspicion of fraud, there was absolutely nothing in the way of direct demonstration. The companies refusing to pay the claims at maturity, suits were promptly instituted under each policy.

At the inquest it was observed that, although the extremities were more or less consumed, the head was entire, and it was believed the bones of the skull, including the teeth, were uninjured. Any peculiarity of the teeth, whether natural or arising from mechanical dentistry, might at once determine the question of identity of these remains. An effort was made to obtain a description of any peculiarity, if it existed, for the purpose indicated. In pursuance of this information every dentist in Baltimore was interrogated, but with only negative results. So far as could be ascertained, Goss was known to have unusually good teeth, which were conspicuous in his ordinary conversation and were fully exposed when he laughed. From no source could it be learned that he had had occasion to employ a dentist.

Mrs. Goss had testified before the coroner to certain facts touching the *personnel* of the supposed deceased. She was therefore requested to make a more elaborate description, especially of his teeth, and to grant permission for the exhumation and examination of the remains. This was the proposition in regard to the teeth: Furnish "description of his teeth, their quality and appearance; whether wholly or partially sound or defective, natural or artificial; whether he had any peculiar teeth, had lost any, and how many and what teeth; had any teeth broken, and how many and what teeth, and how broken; had any teeth filled or otherwise operated upon by a dentist, and how, where, and when operated upon, and by what dentist." Her reply was: "He wore no artificial teeth to my knowledge, never complained of pain or inconvenience from decayed teeth, and I do not remember his requiring the services of a dentist during the time we lived together. I should call his front teeth quite regular."

The remains were exhumed and examined in the Baltimore College of Dental Surgery by Professor F. T. Miles, M. D.; R. Wysong, M. D.; Prof. E. Lloyd Howard, M. D.; and Prof. F. J. S. Gorgas, M. D., D. D. S.

The medical experts who examined the exhumed body were able to say little that could throw light on its identity with W. S. Goss except in the matter of teeth. The physicians stated: (1) The remains were those of a male; (2) he was not a negro; (3) he was between the ages of twenty-five and fifty years; (4) he was of fair average height, of stout build, and of great muscular strength; (5) it is impossible to determine whether the burning was the cause of death or was post-mortem.

But Prof. Gorgas, the dentist, was able to give more valuable opinions. The maxillary bones and teeth were thus fully described by him:

"CONDITION OF MAXILLARY OR JAW-BONES.—*Superior Maxillary*—Perfect, except margin of alveolar process. *Inferior Maxillary*—A portion of the external surface of body of the bone below the alveolar process and to the right of the median line, including the right mental foramen, destroyed for a space of two and a half inches long and one inch broad or wide; the bone otherwise perfect.

"Number of teeth remaining in upper jaw, two; number of teeth remaining in lower jaw (including one root of tooth), seven.

"CONDITION OF THE TWO TEETH IN UPPER JAW.—*Superior Right Second Bicuspid*—A superficial carious cavity on posterior proximal surface. Cusps on grinding surface worn away by mechanical abrasion, but not so much as wholly to obliterate the natural depressions on this surface. *Superior Right Third Molar*—Perfectly sound.

"CONDITION OF THE SEVEN TEETH IN LOWER JAW.—*Root of Inferior Right Central Incisor*—The crown evidently destroyed by caries to a point below free margin of the gum before death. *Inferior Right Lateral Incisor*—Perfectly sound. *Inferior Right Canine*—Sound; angle worn away by mechanical abrasion. *Inferior Left Central Incisor*—Various cavities on both proximal surfaces, which communicated. *Inferior Left Canine*—Carious cavity on the anterior proximal surface. *Inferior Left Second Bicuspid*—Small carious cavity on the anterior proximal surface. *Inferior Left Third Molar*—Large carious cavity on the buccal surface, near neck; also a superficial cavity on grinding surface. Grinding surface worn by mechanical abrasion, so as almost to obliterate the natural depressions on the surface.

"FORM OF IRREGULARITY OF INFERIOR FRONT TEETH.—Proximal surfaces of the inferior right lateral incisor and inferior left central incisor approach near together at the cutting edges, caused by the loss of the crown of the right central incisor, the root of this latter tooth remaining in the alveolar cavity."

No tokens of the wearing of any artificial teeth were discovered. This careful and critical examination could not be reconciled with the statement of Mrs. Goss describing the mouth of her husband. As Mrs. Goss had been married to W. S. Goss fourteen years, during which time they had lived together, it was fair to presume she necessarily would have heard complaints of pain and inconvenience from such badly-decayed teeth and jaws; that she would have remembered the required services of the dentist who had extracted so many of the teeth; and that she would not have called such front teeth "quite regular."

The trial began May 27, 1873, in the Circuit Court of the United States. The defence was conducted by counsel of the several insurance companies interested, all of whom were members of the Baltimore bar. The descriptions of W. S. Goss given at the trial were so singularly consonant with one another as to show him to have been a man of very marked and noticeable form of face. Especially he was said to have had

unusually large, fine teeth. Upon the trial, then, these teeth formed the defendants' *pièce de résistance.* Their witnesses stated that they had often noticed them when Goss talked or smiled.

The companies broke down in the attempt to prove that W. S. Goss had been alive since Feb. 2, 1872. Their counsel, however, came up manfully to the more difficult task of proving affirmatively that the corpse was that of some other person than the insured.

Prof. E. Lloyd Howard testified (in regard to body exhumed):

"Of the sixteen teeth belonging to the upper jaw, nine had been lost before death; by that I mean some time before death. There remained in the upper jaw two teeth; there had fallen out since death three teeth; and two sockets which had once contained teeth were shallow, so that it was uncertain whether these teeth had been lost before or after death. Nine of the sixteen teeth were certainly lost long before death, and two others possibly were. One of the teeth lost in the upper jaw was a front tooth. Of the teeth belonging to the lower jaw, seven were lost long before death. One tooth had been partially destroyed by disease. One root of a tooth and eight teeth remained in the jaw. Of the seven teeth lost, six were back teeth, and one was a front tooth, and the one of which the root only remained was a front tooth. This would have given the appearance of two front teeth lost from the lower jaw.

"Of the thirty-two teeth, sixteen were unquestionably lost before death, and of the sixteen remaining, one was only a root in the socket. The crowns of two of the front teeth approached each other over where a tooth had been lost. In the upper jaw the palatine canal, which perforates the roof of the mouth just behind the two middle front teeth, was greatly enlarged by an abscess which had existed previous to death, and which abscess communicated with the diseased cavity of one of the front teeth. The abscess appeared to have formed about the root of the tooth. In our opinion, this abscess, communicating with the cavity in the bone, had absorbed or eaten through the bone to that extent, forming an opening between the socket of the tooth and this anterior palatine canal. It must have been considerably diseased to have left such lesions in the bone. It could not have been otherwise than very painful. We judged from the facts pointed out that the other teeth over the diseased root must have approached each other, giving a crooked, irregular appearance. (Plaster model of mouth handed to witness.) I have examined the model before, and found it corresponded very accurately with the jaws we examined."

Prof. F. J. S. Gorgas, who united in the report of the examination of the remains, and had prepared plaster casts of the mouth which were used by witnesses in their testimony relative to the teeth, was unable to testify, being absent on account of the illness of a daughter who was on a visit to a Western city. Dr. Gorgas's evidence being unattainable, Dr. Robert Arthur was called for the defendants, and testified:

"I have practised the profession of dentistry for thirty-two years. (Plaster models of the mouth of subject handed to witness.) The operations of nature after a loss of teeth during life are such as to leave it a matter of no possible scientific doubt whether teeth have been lost before or after death, provided they have been lost a certain time before death. Looking at this model of the lower jaw, speaking as a scientific expert, I would say these teeth were lost, with the exception of the two from these two cavities (referring to the two where the teeth had fallen out since death), certainly more than two years before the death of the subject. In this model of the upper jaw three of the teeth, I should say, were recently lost. The tooth next to

the front tooth has been lost unquestionably from one to two years. The absorption seems to have been complete, but the eye-tooth and the tooth next to it seem not to have been lost so long; the absorption has not been completed. I should infer from the small cavities that the front tooth had been lost some time before death. Obviously, there was a great deal of disease here; there must have been much physical pain. This place where the penetration appears to have taken place in the roof the mouth shows a perforation through the bone communicating with the socket of the teeth. The teeth must have been very much diseased to have got into this condition. Not within my experience have so many teeth been lost without the patient suffering great pain, and of necessity requiring the services of a dentist. In masticating ordinary food the patient must have found great difficulty. He must have eaten with great discomfort. I would not by any means call the person's front teeth 'quite regular.' Teeth that are absent could scarcely be called regular. Even the teeth of the lower jaw must have presented a very irregular appearance."

Dr. Charles H. Ohr of Cumberland (plaster casts of the mouth of the exhumed subject handed to witness): "It was a very irregular set. In my judgment he required the services of a dentist on more occasions than one, and had suffered a great deal of pain on account of diseased teeth. There is very little surface here for mastication or chewing of food. The grinding teeth are not opposite each other in such a way as to enable the person to masticate ordinary usual food. The abscess at the roof the mouth would have produced intense pain."

The case was given to the jury, who returned a verdict in favor of Mrs. Goss for full amount of insurance, with interest added. Defendants' counsel gave notice of motion for a new trial.

This was the end of the first act. Tragic events followed. The verdict was rendered June 6, 1873. Almost directly after this (July 1st or 2d), the motion still pending, news came that the body of a murdered man had been discovered in Chester county, Pennsylvania. The story was that William E. Udderzook arrived there June 30th, accompanied by a man whom Udderzook spoke of as his friend, but did not mention any name. A jury of inquest found "that the same man (name unknown) came to his death from wounds inflicted by a dirk-knife or other sharp instrument in the hands of William E. Udderzook of Baltimore, Maryland."

The fact of Udderzook having been principal witness of the fire on the York Road, coupled with the fact that the remains of the missing stranger bore a striking resemblance to the description of Goss, arrested attention. A careful investigation was at once commenced. All the measurements of the body, muscular development, figure, and general appearance, corresponded accurately with the well-known description of Winfield S. Goss. The teeth were remarkably good, regular, even, and well preserved. The remains were fully identified by Baltimore citizens who knew Goss intimately during his lifetime.

Udderzook was arrested July 15th, and on the 21st of October following the case came to trial.

The indictment contained two counts—one charging the prisoner with the murder of W. S. Goss, the other charging him with the murder of a person unknown. The defendant's counsel insisted that the prosecution should decide upon which count it would proceed. The district attorney boldly announced his resolution to elect the count for the murder of W. S. Goss. The government thus assumed the double burden of proving not only the murder, but also the identity of the murdered man with one who,

there was at least strong evidence to show, had died a year and a half before the alleged commission of the crime. The charge of killing W. S. Goss, however, opened at once an immense field of testimony, otherwise incomplete and altogether meaningless, in which the motive became abundantly apparent. Obviously, by the fearless assumption of the greater burden lay also the greater, indeed the only, assurance of success.

The government made out an elaborate and perfect narrative, no material part of which was powerfully assailed by the prisoner. Udderzook really presented nothing worthy to be called a defence. He did not produce A. C. Wilson (*alias* W. S. Goss) or any trace of him; he did not explain who Wilson was, or what was the origin of his own acquaintance or the nature of his own connection with that mysterious person, who was allowed to cross the scene, coming out of mystery, and in a few months plunging again into even more profound obscurity, and during his brief sojourn in the known world proved to have had prior acquaintance with no persons save Udderzook and A. C. Goss.

Dr. E. W. Bailey testified: "I found the front teeth, the four upper incisors, and the four below had been driven back into the mouth; two of them were lying loose on the tongue and the others were adhering. I removed them all from the mouth, and have kept them in my possession. The person had what I would call a very good set of teeth; they were firm and large and appeared healthy and strong."

Dr. E. Lloyd Howard: "The upper front teeth had been driven back into the mouth, carrying with them a part of the sockets of the teeth. I found ten teeth remaining in the upper jaw, and open, fresh sockets from which four others had been removed recently. Two upper teeth had been lost previous to death. In the lower jaw I found nine teeth remaining in position, and evidence that five others had been lost immediately after death or immediately preceding it. There were evidences of two lower jaw-teeth having been lost some months previous to death. At the time of death he must have had twenty-eight teeth in all remaining in his mouth. The teeth lost previous to death, both in the upper and lower jaw, were back teeth. The general appearance and character of his teeth were perfectly good. They were white, even, and regular. There were three or four gold fillings, and there were slight marks of disease upon two teeth."

The evidence completely overwhelmed Udderzook on his trial. The verdict was murder in the first degree.

The counsel for the defendant had taken a great many exceptions, all relating to facts and circumstances bearing on the question of identity, but not one of them was ultimately sustained by the Supreme Court of Pennsylvania. Their multitude only denotes that the circumstances were numerous, and in this multiplication consists the strength of the proof.

(For other cases bearing on this question the reader is directed to the very suggestive and original paper of Dr. Richard Grady, read before the Maryland and District of Columbia Dental Association at Baltimore, Oct., 1883, and reprinted in the *American Journal of Dental Science*, for January, 1884, and in pamphlet form. From this paper, by the author's courtesy, the case of Goss is taken.)

Statutes Regulating the Practice of Dentistry.

On the general subject of dental legislation the following suggestive remarks are reproduced from "The History of Dental and Oral Science

in America," prepared under the direction of the American Academy of Dental Science, and published in 1876:

"In the earlier days of American dentistry, although there existed even a greater necessity for some barrier to the promiscuous entrance into the profession of unqualified persons than is now felt, there were insuperable objections in the minds of even reputable and competent practitioners to any application for legal protection. Chief among these stood that almost universally predominant feeling of professional jealousy which was so long the barrier to advancement in dentistry in almost every direction. To appeal to public guardianship was to display their modes of practice, not alone to the public and unprofessional eye, but to the scrutiny of, and perchance adoption by, the professional brotherhood. Narrow and illiberal as such a view will now appear, it is no less the exact one taken by the general practitioner of fifty years ago on almost any question connected with his practice. Good dentists were few and isolated, and easily commanded upon their merits all the practice they could care for, and they consequently contented themselves with railing at such dental operators as were, or as they conceived to be, below them in scientific or practical status, being well aware that they were secure in the position they had gained in the public estimation, and caring little for aught else. It will be remembered that we refer to the general practitioner, and do not include some who from the earliest dates appear to have been entirely free from such ignoble motives.

"There was another fact which also operated strongly against any movement of the better class of dentists toward legislative protection against empiricism. This was, that the majority of persons practising dentistry in this country was in those times composed of the very class against which any such enactment would, perforce, have been aimed. This class, although certainly not influential in individuality, was yet so as a whole, and could not be ignored—and might possibly not have been overcome—in any contest such as would surely have arisen on the question of dental legislation.

"Upon the establishment of dental periodicals and schools, and in consequence of the growth of liberal ideas in the profession, the state of affairs in dentistry gradually changed. A college degree and an official published organ gave to the educated dentist of 1840 and afterward a superiority in the public estimation over the irregular practitioner which he had never before held, and enabled him to concert and complete measures such as would have been exceedingly difficult, if not impossible, to have been carried out even five years before.

"Curiously enough, the first State to pass a dental enactment in this country was Alabama, almost the poorest in skilled dentists at the time of any State in the Union. This legislation (probably the first ever had on the dental specialty) was somewhat anomalous, placing the keeping of dental interests entirely in the hands of the general surgeon and physician. The old and now well-known objections to such a course operated then much more actively than they do at present. Said Dr. Harris:[1] 'The insuperable objection to committing the interests of den-

[1] *American Journal of Dental Science*, 1st Series, vol. iii. p. 291.

tal surgery into the keeping of the general surgeon and the physician is, that gentlemen who are only medically educated, as far as it regards dental surgery are oftentimes as ignorant as the most unlearned. The medical colleges have never taught this branch of surgery in its most important and difficult operations, and hundreds of students are graduated yearly who do not really know how to extract a tooth scientifically.' It is worthy of note that Dr. Harris, in conclusion of the above remarks, outlined almost exactly the present system of associated dentistry more than thirty years ago. He adds, referring to the Alabama law, 'Much may be done, even in this way, but the true remedy lies in the general union of educated dentists in a central association, aided and sustained by State societies. Such, acting with as much power from the State laws as surgeons and physicians have, will be able to make the profession honorable, respectable, and useful.'"

ALABAMA.[1]—The act of Alabama was approved December 31, 1841. It reads as follows:

An Act Regulating the Practice of Dental Surgery, and for other purposes.

Section 1. Be it enacted by the Senate and House of Representatives of the State of Alabama, in General Assembly convened, That from and after the first Monday in December next it shall be the duty of each of the medical boards of this State to examine and license applicants to practise dental surgery, under the same rules and regulations and subject to the same restrictions as those who apply for license to practise medicine; and, in order more fully to carry this act into effect, it shall be the duty of each of the medical boards, where the same is practicable, to add to their body, by election, a professional dentist having the requisite qualifications, which dentist so added shall constitute a part of the board.

Sec. 2. And be it further enacted, That if any person styling himself as dentist, or other person, shall engage in the practice of dental surgery as a professional business, after the aforesaid first Monday in December next, without having been regularly licensed so to do by one of the medical boards of this State, as hereinbefore provided for, for every such offence shall forfeit and pay a sum not exceeding fifty dollars, recoverable before any court having jurisdiction of the same, one-half to the informer, the other half to the county where suit is brought.

Sec. 3. And be it further enacted, That all bonds, notes, or promissory obligations or assumpsits made to any person or persons not authorized as provided for in this act, the consideration of which shall be for services rendered as a professional dentist or in the line of professional dentistry, shall be utterly void and of no effect; *provided,* The provisions of this act shall not be so construed as to prevent persons from practising dental surgery who have a license to practise surgery and medicine from either of the medical boards of this State, or diploma from any regularly-constituted institution in the United States.

Sec. 4. And be it further enacted, That hereafter it shall be the duty of all practising physicians, surgeons, and dentists to have their licenses recorded in the office of the clerk of the county court in which they may reside; and the certificate of the clerk shall be considered as good evidence in any court of the right of any individual having a diploma or license to practise his profession and recover his debts for the same.

[1] See Appendix, p. 1017, for new law.

Sec. 5. And be it further enacted, That all laws and parts of laws contravening the provisions of this act be and the same are hereby repealed.

This act continued upon the statute-books until the year 1881, when a new act was passed by the Legislature. The following is the text of the enactment:

An Act to Regulate the Practice of Dentistry in the State of Alabama.

Section 1. Be it enacted by the General Assembly of Alabama, That from and after the passage of this act it shall be unlawful for any person to engage in the practice of dentistry in the State of Alabama unless said person has obtained license from a board of dental examiners duly authorized and appointed by this act to issue such license; *provided*, That dentists who have been in the regular practice of dentistry for five years next preceding the passage of this act shall not be required to submit to an examination, and shall be entitled to license without fee, which shall be transmitted to him by mail or otherwise upon his application accompanied by an affidavit to the fact of his having been in the regular practice for the required time.

Sec. 2. Be it further enacted, That the board of dental examiners shall consist of five (5) dental graduates or practitioners of dentistry who have obtained a license to practise dentistry from a medical board in this State or from a dental board organized under this act, and who are members in good standing of the Alabama Dental Association; *provided*, That said graduates or practitioners have been practising dentistry in the State of Alabama for a period not less than three (3) years; *and provided further*, That the first board of examiners under this act shall consist of the present executive committee of the Alabama Dental Association, who shall hold office until the next annual meeting of the said association; and until their successors are elected and qualified as hereinafter provided.

Sec. 3. Be it further enacted, That it shall be the duty of the said Alabama Dental Association, at its annual meeting next after the passage of this act and every two years thereafter, to elect said board of examiners, who shall hold office for the term of two (2) years and until their successors are elected and qualified. The president of said association shall have power to fill all vacancies in said board for unexpired terms.

Sec. 4. Be it further enacted, That it shall be the duty of said board of examiners—

1st. To meet annually at the time and place of meeting of the Alabama Dental Association, or oftener at the call of any three of the members of said board. Thirty days' notice must be given of the time and place of meeting of said board, said notice to be mailed to all practising dentists in the State.

2d. To prescribe a course of reading for those who study dentistry under private instruction.

3d. To grant a license to any applicant who shall furnish satisfactory evidence of having graduated and received a diploma from any incorporated dental college, or who has heretofore received a license from a medical board in this State, without examination or fee.

4th. To grant license to all other applicants who undergo a satisfactory examination, who shall pay to the said board a fee of five dollars for said license.

5th. To keep a book in which shall be registered the names of all persons licensed to practise dentistry in this State.

Sec. 5. Be it further enacted, That the book so kept shall be a book of record, and a transcript from it, certified to by the officer who has it in keeping, with the common seal of said board, shall be evidence in any court of this State.

Sec. 6. Be it further enacted, That three members of said board shall constitute a quorum for the transaction of business; and should a quorum not be present on the day appointed for its meeting, those present may adjourn from day to day until a quorum is present.

Sec. 7. Be it further enacted, That one member of said board may grant a license for an applicant to practise until the next regular meeting of the board, when he shall report the fact, at which time the temporary license shall expire; but such temporary license shall not be granted by a member of the board after the board has rejected the applicant.

Sec. 8. Be it further enacted, That any person who shall, in violation of this act, practise dentistry in this State for a fee or reward shall be liable to indictment, and on conviction shall be fined not less than fifty nor more than three hundred dollars; *provided*, That nothing in this act shall be construed to prevent persons from extracting teeth.

Sec. 9. Be it further enacted, That on the trial of such indictment it shall be incumbent upon the defendant, to exempt him from the penalties of this act, to show that he has authority under the law to practise dentistry in this State.

Sec. 10. Be it further enacted, That every person to whom license is issued by said board of examiners shall, within thirty days from the date thereof, present the same to the judge of the probate court of the county in which he resides, who shall officially indorse said license and seal it with the seal of the court, and who shall record said license in a proper book in his office, and who shall be entitled to receive a fee of one (1) dollar for his services; but a temporary license issued under Section 7 of this act need not be sealed or recorded.

Sec. 11. Be it further enacted, That it shall be the duty of the solicitors of this State to prosecute all persons violating all or any portion of this act.

Sec. 12. Be it further enacted, That all laws or parts of laws in conflict with this act be, and the same are hereby, repealed.

Approved February 11, 1881.

California.—The following is the text of "an act to ensure the better education of practitioners of dental surgery and to regulate the practice of dentistry in the State of California:"

The people of the State of California, represented in Senate and Assembly, do enact as follows:

Section 1. It shall be unlawful for any person who is not at the time of the passage of this act engaged in the practice of dentistry in this State to commence such practice unless he or she shall have obtained a certificate as hereinafter provided.

Sec. 2. A board of examiners, to consist of seven practising dentists, is hereby created, whose duty it shall be to carry out the purposes and enforce the provisions of this act. The members of said board shall be appointed by the governor from the dental profession of the State at large. The term for which the members of said board shall hold their offices shall be four years, except that two of the members of the board, first to be appointed under this act, shall hold their office for the term of one year, two for the

term of two years, two for the term of three years, and one for the term of four years, respectively, and until their successors shall be duly appointed and qualified. In case of a vacancy occurring in said board, such vacancy shall be filled by the governor in conformity with this section.

Sec. 3. Said board shall choose one of its members president and one the secretary thereof, and it shall meet at least once in each year, and as much oftener and at such times and places as it may deem necessary. A majority of said board shall at all times constitute a quorum, and the proceedings thereof shall at all reasonable times be open to public inspection.

Sec. 4. Within six months from the time that this act takes effect it shall be the duty of every person who is now engaged in the practice of dentistry in this State to cause his or her name and residence or place of business to be registered with said board of examiners, who shall keep a book for that purpose. The statement of every such person shall be verified under oath before a notary public or justice of the peace in such manner as may be prescribed by the board of examiners. Every person who shall so register with said board as a practitioner of dentistry shall receive a certificate to that effect, and may continue to practise as such without incurring any of the liabilities or penalties provided in this act, and shall pay to the board of examiners for such registration a fee of one dollar. It shall be the duty of the board of examiners to forward to the county clerk of each county in the State a certified list of the names of all persons residing in his county who have registered in accordance with the provisions of this act, and it shall be the duty of all county clerks to register such names in a book to be kept for that purpose.

Sec. 5. Any and all persons who shall so desire may appear before said board at any of its regular meetings, and be examined with reference to their knowledge and skill in dental surgery; and if the examination of any such person or persons shall prove satisfactory to said board, the board of examiners shall issue to such persons as they shall find to possess the requisite qualifications a certificate to that effect, in accordance with the provisions of this act. Said board shall also indorse as satisfactory diplomas from any reputable dental college when satisfied of the character of such institution, upon the holder furnishing evidence satisfactory to the board of his or her right to the same, and shall issue certificates to that effect within ten days thereafter. All certificates issued by said board shall be signed by its officers, and such certificates shall be *primâ facie* evidence of the right of the holder to practise dentistry in the State of California.

Sec. 6. Any person who shall violate any of the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction may be fined not less than fifty dollars nor more than two hundred dollars, or be confined six months in the county jail, for each and every offence. All fines recovered under this act shall be paid into the common-school fund of the county in which such conviction takes place.

Sec. 7. In order to provide the means for carrying out and maintaining the provisions of this act the said board of examiners shall charge each person applying to or appearing before them for examination for a certificate of qualifications a fee of ten dollars, which fee shall in no case be returned; and out of the funds coming into possession of the board from the fees so charged and penalties received under the provisions of this act all legitimate and necessary expenses incurred in attending the meetings of said board shall be paid, and no part of the expenses of the board shall ever be paid out of the State treasury. All moneys received in excess of

expenses above provided for shall be held by the secretary of said board as a special fund for meeting the expenses of said board and carrying out the provisions of this act, he giving such bonds as the board shall from time to time direct. And said board shall make an annual report of its proceedings to the governor by the first of December of each year, together with an account of all moneys received and disbursed by them pursuant to this act.

Sec. 8. Any person who shall receive a certificate from said board to practise dentistry shall cause his or her certificate to be registered with the county clerk of the county in which such person may reside, and the county clerk shall charge for registering such certificate a fee of one dollar. Any failure, neglect, or refusal on the part of any person holding such certificate to register the same with the county clerk as above directed for a period of six months shall work a forfeiture of the certificate; and no certificate, when once forfeited, shall be restored, except upon the payment to the said board of examiners of the sum of twenty-five dollars as a penalty for such neglect, failure, or refusal.

Sec. 9. Any person who shall knowingly and falsely claim or pretend to have or hold a certificate of license, diploma, or degree granted by any society organized under and pursuant to the provisions of this act, or who shall falsely and with intent to deceive the public claim or pretend to be a graduate from any incorporated dental college, shall be deemed guilty of a misdemeanor, and shall be liable to the same penalty as provided in Section 6.

Sec. 10. Nothing in this act shall be so construed as to prohibit any practising physician from extracting teeth.

Sec. 11. This act shall take effect immediately.

Dakota.—The following is the text of an "act to ensure the better education of practitioners of dental surgery and to regulate the practice of dentistry in the Territory of Dakota:"

Be it enacted by the Legislative Assembly of the Territory of Dakota:

Section 1. That it shall be unlawful for any person to engage in the practice of dentistry in this Territory unless he or she shall have obtained a certificate as hereinafter provided.

Sec. 2. A board of examiners, to consist of five practising dentists, is hereby created, whose duty it shall be to carry out the purposes and enforce the provisions of this act. The members of said board shall be appointed by the governor, who shall select them from ten candidates whose names shall be furnished him by the South Dakota Dental Society and the North-western Dental Association; each shall furnish the names of five candidates, and the governor shall select at least two from each five names so furnished to be members of said board. The term for which the members of said board shall hold their offices shall be five years, except that the members of the board first to be appointed under this act shall hold their offices for the term of one, two, three, four, and five years respectively, and until their successors shall be duly appointed. In case of a vacancy occurring in said board, such vacancy shall be filled by the governor from names presented to him by the North-western Dental Association and the South Dakota Dental Society. It shall be the duty of said dental organizations to present twice the number of names to the governor of those to be appointed.

Sec. 3. Said board shall choose one of its members president, and one the secretary thereof, and it shall meet at least once in each year, and as much oftener and at such times and places as it may deem necessary. A majority of said board shall at all times constitute a quorum, and the proceedings thereof shall at all reasonable times be open to public inspection.

Sec. 4. Within six months from the time this act takes effect it shall be the duty of every person who is at that time engaged in the practice of dentistry in this Territory to cause his or her name and residence or place of business to be registered with said board of examiners, who shall keep a book for that purpose.

The statement of every person shall be verified under oath before a notary public or justice of the peace, in such a manner as may be prescribed by the board of examiners.

Every person who shall so register with said board as a practitioner of dentistry may continue to practise the same as such without incurring any of the liabilities or penalties provided in this act, and shall pay to the board of examiners for such registration a fee of one dollar.

It shall be the duty of the board of examiners to forward to the register of deeds of each county in the Territory a certified list of the names of all persons residing in the county who have registered in accordance with the provisions of this act; and it shall be the duty of all registers of deeds to register such names in a book to be kept for that purpose.

Sec. 5. Any and all persons who shall so desire may appear before said board at any of its regular meetings, and be examined with reference to their knowledge and skill in dental surgery; and if the examination of any such person or persons shall prove satisfactory to said board, the board of examiners shall issue to such persons as they shall find to possess the requisite qualifications a certificate to that effect, in accordance with the provisions of this act; said board shall also indorse as satisfactory diplomas from any reputable dental college, when satisfied with the character of such institution, upon the holder of such diploma furnishing evidence satisfactory to the board of his or her right to the same.

All certificates issued by said board shall be signed by its officers, and such certificate shall be *primâ facie* evidence of the right of the holder to practise dentistry in the Territory of Dakota.

Sec. 6. Any person who shall violate any of the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction may be fined not less than fifty dollars nor more than one hundred dollars, or be confined six months in the county jail.

All fines received under this act shall be paid into the common-school fund of the county in which such conviction takes place.

Sec. 7. In order to provide the means for carrying out and maintaining the provisions of this act, the said board of examiners may charge each person applying to or appearing before them for examination for a certificate of qualification a fee of ten dollars, which fee shall in no case be returned; and out of the funds coming into the possession of the board from the fees so charged the members of said board may receive as compensation the sum of five dollars for each day actually engaged in the duties of their office, and all legitimate and necessary expenses incurred in attending the meetings of said board; said expenses shall be paid from the fees and penalties received by the board under the provisions of this act, and no part of the salary or other expenses of the board shall ever be paid out of the Territorial treasury.

All moneys received in excess of said per diem allowance and other

expenses, as above provided for, shall be held by the secretary of said board as a special fund for meeting expenses of said board and carrying out the provisions of this act, he giving such bonds as the board shall from time to time direct.

And said board shall make an annual report of its proceedings to the governor by the 15th of December of each year, together with an account of all moneys received and disbursed by them pursuant to this act.

Sec. 8. Any person who shall receive a certificate of qualification from said board shall cause his or her certificate to be registered with the register of deeds of any county in which such person may desire to engage in the practice of dentistry; and the registers of deeds of the several counties in this Territory shall charge for registering such certificates a fee of twenty-five cents for such registration.

Any failure, neglect, or refusal on the part of any person holding such certificate to register the same with the register of deeds, as above directed, for a period of six months, shall work a forfeiture of the certificate, and no certificate when once forfeited shall be restored, except upon payment to said board of examiners of the sum of twenty-five dollars as a penalty for such neglect, failure, or refusal.

Sec. 9. Any person who shall knowingly and falsely claim or pretend to have or hold a certificate of license, diploma, or degree granted by any society, or who shall falsely and with intent to deceive the public claim or pretend to be a graduate from any incorporated dental college, not being such graduate, shall be deemed guilty of a misdemeanor, and shall be liable to the same penalty as provided in Section 6 of this act.

Sec. 10. This act shall take effect and be in force from and after its passage and approval.

Approved March 10, 1885.

DELAWARE.—The Delaware dental law was passed at Dover, March 31, 1885.

Be it enacted by the Senate and House of Representatives of the State of Delaware in, General Assembly met:

Section 1. That it shall be unlawful for any person who is not, at the time of the passage of this act, a recognized practitioner of dentistry in this State, and so recognized by the profession, to practise dentistry, unless he or she shall have obtained a certificate as hereinafter provided, or shall hold a diploma from a reputable dental college, and so recognized by the board herein created.

Sec. 2. Be it enacted, That a board of examiners, to consist of five reputable practising dentists, is hereby created, whose duty it shall be to carry out the purposes and enforce the provisions of this act; the members of said board shall be appointed by the governor, who shall select them from the dentists residing in the State. The term for which the members of said board shall hold their offices shall be four years, except that two members of the board, first to be appointed under this act, shall be designated by the governor to hold their offices for the term of two and three and four years, respectively, unless sooner removed by the governor, and until their successors shall be duly appointed; in a case of vacancy occurring in such board, such vacancy shall be filled in like manner by the governor.

Sec. 3. Be it enacted, That said board shall choose one of its members president and one secretary thereof; it shall fix the time and place of its meeting or meetings; a majority of said board shall at all times constitute

a quorum, and the proceedings thereof shall at all reasonable times be open to public inspection; the board shall also make an annual report of its proceedings to the governor.

Sec. 4. Be it enacted, That within six months from the time this act takes effect it shall be the duty of every person who is at that time engaged in the practice of dentistry in this State to cause his or her name and residence or place of business to be registered with said board of examiners, who shall keep a book for that purpose; the statement of every such person shall be verified under oath before a notary public or justice of the peace in such a manner as may be prescribed by the said board of examiners. Every person who shall so register with said board as a practitioner of dentistry may continue to practise the same as such, and shall receive a certificate of such registration upon his or her paying the said board one dollar for such certificate.

Sec. 5. Be it enacted, That any and all persons who shall desire to commence such practice after the passage of this act shall appear before said board at any of its regular meetings, and be examined with reference to their knowledge and skill in dental surgery; and if the examination of any such person or persons shall prove satisfactory to said board, the board of examiners shall issue to such persons as they shall find to possess the requisite qualifications a certificate to that effect, in accordance with the provisions of this act, upon the payment of one dollar for such certificate; all certificates issued by said board shall be signed by its officers, and such certificates and diplomas, granted as aforesaid, shall be *primâ facie* evidence of the right of the holder to practise dentistry in the State of Delaware.

Sec. 6. Be it enacted, That any person who shall wilfully violate any of the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction thereof in any court having criminal jurisdiction may be fined not less than fifty dollars nor more than three hundred dollars, or be confined not more than six months in the county jail, in the discretion of the court; all fines received under this act shall be paid into the common-school fund of the city or county in which such conviction takes place.

Sec. 7. Be it enacted, That the board of examiners shall meet within thirty days after appointment and frame by-laws governing the board; and any person or persons desiring to be examined by the board of examiners for a certificate to practise dentistry in this State shall give notice of such desire to the secretary of said board, who shall notify the members thereof, and they shall, within fifteen days from the receipt of such notice, meet to examine such person or persons, and give him, her, or them proper notice of such meeting.

Sec. 8. Be it enacted, That this act shall not apply to any one now practising who is the owner of and purchased real estate in the State previous to the passage of this act.

Sec. 9. Be it enacted, That this act shall take effect from the date of its passage.

GEORGIA.—*An Act to Regulate the Practice of Dentistry, and to Protect the People against Empiricism in Relation thereto, in the State of Georgia.*

Section 1. Be it enacted by the General Assembly, That from and after the passage of this act it shall be unlawful for any person to engage in the practice of dentistry in the State of Georgia unless said person has graduated and received a diploma from the faculty of a dental college chartered under the authority of some one of the United States or foreign

governments, or shall have obtained a license from a board of dentists duly authorized and appointed by this act to issue such license.

Sec. 2. That the board of examiners shall consist of five (5) dental graduates or practitioners of dentistry who are members in good standing of the Georgia State Dental Society; *provided*, That said graduates or practitioners have been practising in the State of Georgia for a term of not less than three (3) years. Said board shall be elected to serve for two years. The president of said Georgia State Dental Society shall have power to fill all vacancies in said board for unexpired terms.

Sec. 3. That it shall be the duty of this board—first, to meet annually at the time of meeting of the Georgia State Dental Society, or oftener at the call of any three of the members of said board. Thirty days' notice must be given of the annual meetings. Secondly, to prescribe a course of reading for those who study dentistry under private instruction. Thirdly, to grant a license to any applicant who shall furnish satisfactory evidence of having graduated and received a diploma from any incorporated dental college, without fee, charge, or examination. Fourthly, to grant license to all other applicants who undergo a satisfactory examination. Fifthly, to keep a book in which shall be registered the names of all persons licensed to practise dentistry in the State of Georgia.

Sec. 4. That the book so kept shall be a book of record, and a transcript from it, certified to by the officer who has it in keeping, with the common seal, shall be evidence in any court in the State.

Sec. 5. That three members of said board shall constitute a quorum for the transaction of business; and should a quorum not be present on the day appointed for their meeting, those present may adjourn from day to day until a quorum is present.

Sec. 6. That one member of said board may grant a license to an applicant to practise until the next regular meeting of the board, when he shall report the fact, at which time the temporary license shall expire; but such temporary license shall not be granted by a member of the board after the board has rejected the applicant.

Sec. 7. That any person who shall, in violation of this act, practise dentistry in the State of Georgia for a fee or reward shall be liable to indictment, and on conviction shall be fined not less than fifty or more than three hundred dollars; *provided*, That nothing in this act shall be construed to prevent any person from extracting teeth; *and provided further*, That none of the provisions of this act shall apply to regularly licensed physicians and surgeons.

Sec. 8. That on trial of such indictment it shall be incumbent on the defendant to show that he has authority, under the law, to practise dentistry, to exempt himself from such penalty.

Sec. 9. That one-half of all fines collected shall inure to the informer, and the other half to the educational fund of the county.

Sec. 10. That dentists who have been in practice prior to the passage of this act are exempt from all provisions of the same.

Sec. 11. Repeals conflicting laws.

Approved August 24, 1872.

An amendment was passed and approved October 9, 1885, of which the following is the text:

Section 1. Be it enacted by the General Assembly, That from and after the passage of this act it shall be unlawful for any person to engage in the

practice of dentistry in the State of Georgia unless said person *shall have obtained a license from a board of dentists duly authorized and appointed under the provisions of this chapter to issue license.*

Sec. 2. That the board of examiners shall consist of five dental graduates or practitioners of dentistry who are members in good standing of the Georgia State Dental Society; *provided,* That said graduates or practitioners have been practising in the State of Georgia for a term of not less than three years. Said board shall be elected to serve for two years. The president of said Georgia State Dental Society shall have power to fill all vacancies in said board for unexpired terms.

Sec. 3. That it shall be the duty of this board—First, to meet annually at the time of meeting of the Georgia State Dental Society, or oftener at the call of any three members of said board. Thirty days' notice must be given of the annual meetings. Secondly, to prescribe a course of reading for those who study dentistry under private instruction. *Thirdly, to grant license to all applicants who undergo a satisfactory examination. Fourthly, to keep a book in which shall be registered the names of all persons licensed to practise dentistry in the State of Georgia.*

Sec. 4. That the book so kept shall be a book of record, and a transcript from it, certified to by the officer who has it in keeping, with the common seal, shall be evidence in any court in the State.

Sec. 5. That three members of said board shall constitute a quorum for the transaction of business, and should a quorum not be present on the day appointed for their meeting, those present may adjourn from day to day until a quorum is present.

Sec. 6. That one member of said board may grant a license to an applicant to practise until the next regular meeting of the board, when he shall report the fact, at which time the temporary license shall expire; but such temporary license shall not be granted by a member of the board after the board has rejected the applicant.

Illinois.—The Illinois bill is the outcome of a dozen years of effort to secure the passage of a law for the governance of practice and the protection of the people against quackery. In several features it will be found to differ materially from any of the acts in force in States having legislation on the subject:

A Bill for an Act to Ensure the Better Education of Practitioners of Dental Surgery, and to Regulate the Practice of Dentistry in the State of Illinois.

Be it enacted by the people of the State of Illinois represented in the General Assembly:

Section 1. That it shall be unlawful for any person who is not at the time of the passage of this act engaged in the practice of dentistry in this State to commence such practice unless such person shall have received a diploma from the faculty of some reputable dental college duly authorized by the laws of this State or of some other of the United States, or by the laws of some foreign country, in which college or colleges there was at the time of the issue of such diploma annually delivered a full course of lectures and instructions in dental surgery; *provided,* That any person removing into this State, who shall have been for a period of ten years prior to such removal a practising dentist, and *provided also,* That any person holding the diploma of doctor of medicine from any reputable medical college, shall be entitled to practise dentistry in this State upon

obtaining a license for the purpose as hereinafter provided; and nothing in this act shall be construed to prohibit any physician or surgeon from extracting teeth.

Sec. 2. A board of examiners, to consist of five practising dentists, is hereby created, whose duty it shall be to carry out the purposes and enforce the provisions of this act. The members of said board shall be appointed by the governor.

The term for which the members of said board shall hold their offices shall be five years, except that the members of the board first to be appointed under this act shall hold their offices for the term of one, two, three, four, and five years respectively, and until their successors shall be duly appointed.

In case of a vacancy occurring in said board such vacancy shall be filled by the governor.

Sec. 3. Said board shall choose one of its members president, and one the secretary thereof, and it shall meet at least once in each year, and as much oftener and at such times and places as it may deem necessary. A majority of said board shall at all times constitute a quorum, and the proceedings thereof shall at all reasonable times be open to public inspection.

Sec. 4. It shall be the duty of every person who is engaged in the practice of dentistry in this State, within six months from the date of the passage of this act, to cause his or her name and residence or place of business to be registered with said board of examiners, who shall keep a book for that purpose; and every person who shall so register with said board as a practitioner of dentistry may continue to practise the same as such without incurring any of the liabilities or penalties provided in this act.

Sec. 5. No person whose name is not registered on the books of said board as a regular practitioner of dentistry within the time prescribed in the preceding section shall be permitted to practise dentistry in this State until such person shall have been duly examined by said board and regularly licensed in accordance with the provisions of this act.

Sec. 6. Any and all persons who shall so desire may appear before said board at any of its regular meetings and be examined with reference to their knowledge and skill in dental surgery; and if the examination of any such person or persons shall prove satisfactory to said board, the board of examiners shall issue to such persons as they shall find from such examination to possess the requisite qualifications a license to practise dentistry in accordance with the provisions of this act. But said board shall at all times issue a license to any regular graduate of any reputable dental college without examination, upon the payment by such graduate to the said board of a fee of one dollar. All licenses issued by said board shall be signed by the members thereof and be attested by its president and secretary; and such license shall be *primâ facie* evidence of the right of the holder to practise dentistry in the State of Illinois.

Sec. 7. Any member of said board may issue a temporary license to any applicant, upon the presentation by such applicant of the evidence of the necessary qualifications, to practise dentistry; and such temporary license shall remain in force until the next regular meeting of said board occurring after the date of such temporary license, and no longer.

Sec. 8. Any person who shall violate any of the provisions of this act shall be liable to prosecution before any court of competent jurisdiction upon information or by indictment, and upon conviction may be fined not

less than twenty-five dollars nor more than fifty dollars for each and every offence. All fines recovered under this act shall be paid into the common-school fund of the county in which such conviction takes place.

Sec. 9. In order to provide the means for carrying out and maintaining the provisions of this act, the said board of examiners may charge each person applying to or appearing before them for examination for license to practise dentistry a fee of two dollars; and out of the funds coming into the possession of the board from the fees so charged the members of said board may receive as compensation the sum of five dollars for each day actually engaged in the duties of their office, and all legitimate and necessary expenses incurred in attending the meetings of said board. Said expenses shall be paid from the fees and penalties received by the board under the provisions of this act, and no part of the salary or other expenses of the board shall ever be paid out of the State treasury. All moneys received in excess of said *per-diem* allowance and other expenses above provided for shall be held by the secretary of said board as a special fund for meeting the expenses of said board, he giving such bond as the board shall from time to time direct. And said board shall make an annual report of its proceedings to the governor by the fifteenth of December of each year, together with an account of all moneys received and disbursed by them pursuant to this act.

Sec. 10. Any person who shall be licensed by said board to practise dentistry shall cause his or her license to be registered with the county clerk of any county or counties in which such person may desire to engage in the practice of dentistry, and the county clerks of the several counties in this State shall charge for registering such license a fee of twenty-five cents for each registration.

Any failure, neglect, or refusal on the part of any person holding such license to register the same with the county clerk, as above directed, for a period of six months, shall work a forfeiture of the license; and no license, when once forfeited, shall be restored, except upon the payment to the said board of examiners of the sum of twenty-five dollars as a penalty for such neglect, failure, or refusal.

INDIANA.[1]—*An Act to Regulate the Practice of Denistry in the State of Indiana.*

Section 1. Be it enacted by the General Assembly of the State of Indiana, That it shall be unlawful for any one to practise dentistry for a fee or reward in the State of Indiana without having received a diploma from a dental college duly incorporated under the laws of this or some other State of the United States, or a certificate of qualification issued by a board of examiners to be appointed by the Indiana State Dental Association; *provided,* That nothing in this act shall apply to any one engaged in the practice of dentistry in this State at the time of the passage of this act.

Sec. 2. A board of examiners, consisting of five practising dentists, shall be appointed by said State Dental Association according to its by-laws, whose duty it shall be to meet annually at the time and place of meeting of the said State Association, or oftener at the call of three members of said board at such time and place as may be designated in said call, and to examine all applicants and issue certificates to all who pass a satisfactory examination.

Sec. 3. Any applicant who furnishes satisfactory proof of having been engaged in a reputable practice of denistry for ten consecutive years imme-

[1] See Appendix, p. 1020, for new law.

diately preceding the time of his application shall be examined only in practical dentistry—operative and mechanical; all others shall be examined in anatomy, physiology, pathology, chemistry, and the theory and practice of surgical and mechanical dentistry.

Sec. 4. All certificates issued under the provisions of this act shall be signed by all the members of said board of examiners, and have the seal of the Indiana State Dental Association affixed, and shall be *primâ facie* evidence of the right of the holder to practise under this act; which right it shall be incumbent on the holder to prove in all prosecutions under the same.

Sec. 5. Any member of the board of examiners may grant a permit to practise until the next meeting of the board, but such permit shall be valid only until said next meeting, and in no case be extended or renewed.

Sec. 6. Any person violating the provisions of this act shall be liable to prosecution upon complaint of any citizen of this State before a justice of the peace, or in any superior court of record, by indictment or information in the county where the offence is committed, and upon conviction shall be fined in any sum not less than fifty nor more than one hundred dollars for each offence; *provided*, Nothing in this act shall be so construed as to prevent physicians or surgeons extracting teeth; and all fines so collected shall belong to the common-school fund of the county where assessed.

Sec. 7. To provide a fund to carry out and enforce the provisions of this act the board of examiners shall, before examination, collect from each applicant the sum of twenty-five dollars; any portion of which there may be remaining after paying necessary expenses attending such examination shall be paid into the treasury of the said State Association, to be used for the purpose for which said fund is hereby created.

Sec. 8. Three members of the board of examiners shall constitute a quorum, and all questions before them shall be decided by a vote of the majority of those present; and should there not be a quorum present on the day of meeting, those present may meet and adjourn from day to day until there is a quorum present.

Sec. 9. The board shall receive, out of the fund created by this act, such compensation for their services as the by-laws of said State Dental Association may provide.

Sec. 10. This act shall be in force from and after its passage, publication, and circulation in the several counties in the State.

Approved May 31, 1879.

IOWA.—*A Bill for an Act to Ensure the Better Education of Practitioners of Dentistry in the State of Iowa.*

Be it enacted by the General Assembly of the State of Iowa:

Section 1. That it shall be unlawful for any person who is not at the time of the passage of this act engaged in the practice of dentistry in the State to commence such practice, unless such person shall have received a license from the board of examiners or some members thereof as hereinafter provided, or a diploma from the faculty of some reputable dental college duly authorized by the laws of the State or by some other of the United States, or by the laws of some foreign country, in which college or colleges there was at the time of the issue of such diploma annually delivered a full course of lectures and instruction in dental surgery.

Sec. 2. A board of examiners is hereby created, whose duty it shall be to carry out the purpose and enforce the provisions of this act. The mem-

bers of such board shall be appointed by the governor, and shall consist of five practising dentists who shall have been engaged in the continuous practice of dentistry in the State for five years or over at the time of or prior to the passage of this act. The term for which the members of said board shall hold their office shall be five years, except that the members of the board first appointed under this act shall hold their office for the term of one, two, three, four, and five years respectively, and until their successors shall be duly appointed. In case of vacancy occurring in said board such vacancy shall be filled by the governor.

Sec. 3. Said board shall choose one of its members president and one the secretary thereof; and it shall meet at least once in each year, and as much oftener and at such time and place as it may deem necessary. A majority of said board shall at all times constitute a quorum, and the proceedings thereof shall at all reasonable times be open to public inspection.

Sec. 4. It shall be the duty of every person who is engaged in the practice of dentistry in the State, within six months from the date of the taking effect of this act, to cause his or her name and residence or place of business to be registered with the said board of examiners, who shall keep a book for that purpose; and every person who shall so register with said board as a practitioner of dentistry may continue to practise the same as such without incurring any of the liabilities or penalties of this act.

Sec. 5. No person whose name is not registered on the books of said board as a regular practitioner of dentistry within the limits prescribed in the preceding section shall be permitted to practise dentistry in this State until such person shall have been duly examined by said board and regularly licensed in accordance with the provisions of this act.

Sec. 6. Any and all persons who shall so desire may appear before said board at any of its regular meetings, and be examined with reference to their knowledge and skill in dental surgery; and if such person shall be found, after having been so examined, to possess the requisite qualifications, said board shall issue a license to such person to practise dentistry in accordance with the provisions of this act. But said board shall at all times issue a license to any regular graduate of any reputable dental college without examination upon the payment by such graduate to the said board of a fee of one dollar. All licenses issued by said board shall be signed by the members thereof, and be attested by its president and secretary; and such license shall be *primâ facie* evidence of the right of the holder to practise dentistry in the State of Iowa.

Sec. 7. Any member of said board shall issue a temporary license to any applicant upon the presentation by such applicant of the evidence of the necessary qualifications to practise dentistry; and such temporary license shall remain in force until the next regular meeting of said board occurring after the date of such temporary license, and no longer.

Sec. 8. Any person who shall violate any of the provisions of this act shall be liable to prosecution before any court of competent jurisdiction upon information, and upon conviction shall be fined not less than twenty-five dollars nor more than fifty dollars for each and every offence.

Sec. 9. In order to provide the means for carrying out and maintaining the provisions of this act the said board of examiners may charge each person applying to or appearing before them for examination for license to practise dentistry a fee of two dollars; and out of the funds coming into the possession of the board from the fee so charged the members of said board may receive as compensation the sum of five dollars for each day

actually engaged in the duties of their office. And no part of the salary or other expenses of the board shall be paid out of the State treasury. All moneys received in excess of said *per-diem* allowance shall be held by the secretary of said board as a special fund for meeting the expenses of said board, he giving such bond as the board shall from time to time direct. The said board shall make an annual report of its proceedings to the governor by the fifteenth of November of each year, together with an account of all moneys received and disbursed by them pursuant to this act.

Sec. 10. Any person who shall be licensed by said board to practise dentistry shall cause his or her license to be registered with the county clerk of any county or counties in which such person may desire to engage in the practice of dentistry; and the county clerks of the several counties in the State shall charge for registering such license a fee of twenty-five cents for each registration. Any failure, neglect, or refusal on the part of any person holding such license to register the same with the county clerk as above directed for a period of six months shall work a forfeiture of the license; and no license when once forfeited shall be restored, except upon the payment to the said board of examiners of the sum of twenty-five dollars as a penalty for such neglect, failure, or refusal.

Sec. 11. Nothing in this act shall be construed to prevent persons from extracting teeth.

Approved March 2, 1882.

KANSAS.—*An Act to Regulate the Practice of Dentistry.*

Be it enacted by the Legislature of the State of Kansas:

Section 1. That it shall be unlawful for any person to practise or attempt to practise dentistry or dental surgery in the State of Kansas without having first received a diploma from the faculty of some reputable dental college, school, or university department duly authorized by the laws of this State or some other of the United States, or by the laws of some foreign government, and in which college, school, or university department there was, at the time of the issuance of such diploma, annually delivered a full course of lectures and instructions in dentistry or dental surgery; *provided,* That nothing in Section 1 of this act shall apply to any person engaged in the practice of dentistry or dental surgery in this State at the time of the passage of this act, except as hereinafter provided; *and provided further,* That nothing in this act shall be so construed as to prevent physicians, surgeons, or others from extracting teeth.

Sec. 2. A board of examiners, consisting of four practising dentists, residents of this State, is hereby created, who shall have authority to issue certificates to persons in the practice of dentistry or dental surgery in the State at the time of the passage of this act, and also to decide upon the validity of such diplomas as may be subsequently presented for registration, as hereinafter provided.

Sec. 3. The members of said board shall be appointed by the governor, and shall serve for a term of four years, excepting that the members of the board first appointed shall hold their offices as follows: Two for two and two for four years respectively, and until their successors are duly appointed. In case of vacancy occurring in said board such vacancy shall be filled by appointment by the governor.

Sec. 4. Said board shall keep a record in which shall be registered the names and residences or places of business of all persons authorized under this act to practise dentistry or dental surgery in this State. It shall elect

one of its members president and one secretary thereof, and it shall meet at least once in each year, and as much oftener and at such times and places as it may deem necessary. A majority of the members of said board shall constitute a quorum, and the proceedings thereof shall be at all times open for public inspection.

Sec. 5. Every person engaged in the practice of dentistry or dental surgery within this State at the time of the passage of this act shall, within six months thereafter, cause his or her name and residence and place of business to be registered with said board of examiners, upon which said board shall issue to such person a certificate duly signed by a majority of the members of said board, and which certificate shall entitle the person to whom it is issued to all the rights and privileges set forth in Section 1 of this act.

Sec. 6. Any person desiring to commence the practice of dentistry or dental surgery within this State after the passage of this act shall, before commencing such practice, file for record in a book kept for such purpose with said board of examiners his or her diploma, or a duly-authenticated copy thereof, the validity of which said board shall have power to determine. If accepted, said board shall issue to the person holding such diploma a certificate duly signed by all or a majority of the members of said board, and which certificate shall entitle the person to whom it is issued to all the rights and privileges set forth in Section 1 of this act.

Sec. 7. To provide for the proper and effective enforcement of this act, said board of examiners shall be entitled to the following fees, to wit: For each certificate issued to persons engaged in practice in this State at the time of the passage of this act, the sum of three dollars; for each certificate issued to persons not engaged in the practice of dentistry in the State at the time of the passage of this act, the sum of ten dollars.

Sec. 8. The members of said board shall each receive the compensation of five dollars per day for each day actually engaged in the duties of their office, which, together with all other legitimate expenses incurred in the performance of such duties, shall be paid from fees received by the board under the provisions of this act; and no part of the expenses of said board shall at any time be paid out of the State treasury. All moneys in excess of said *per-diem* allowance and other expenses shall be held by the secretary of said board as a special fund for meeting the expenses of said board, he giving such bond as the board shall from time to time direct; and such board shall make an annual report of its proceedings to the governor by the fifteenth day of December of each year, together with an account of all moneys received and disbursed by them in pursuance of this act.

Sec. 9. Any person who shall violate this act by practising or attempting to practise dentistry within the State without first complying with the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined in a sum not less than ten dollars nor more than one hundred dollars.

Sec. 10. This act shall take effect and be in force from and after its publication in the statutes.

KENTUCKY.—*An Act to Amend an Act entitled "An Act to Incorporate the State Dental Association."*

Section 1. Be it enacted by the General Assembly of the Commonwealth of Kentucky, That it shall be unlawful for any person to practise dentistry in the State of Kentucky for compensation unless such person has received

a diploma from the faculty of a dental college duly incorporated under the laws of this or any other of the United States or foreign country, or a certificate of qualification issued by the Kentucky State Dental Association; *provided*, That nothing in this section shall apply to persons now engaged in the practice of dentistry in this State.

Sec. 2. There shall be a board of examiners, to consist of three practitioners of dentistry, who, together with the president and secretary of the Kentucky Dental Association, shall be elected by said Dental Association according to its by-laws.

Sec. 3. It shall be the duty of said board of examiners, so elected, to meet annually at the time of meeting of said Kentucky State Dental Association, or oftener at the call of any three of the members of said board or of an applicant for a certificate to practise dentistry.

Sec. 4. Thirty days' notice must be given of the annual meetings of said State Association, and previous thereto, that all applicants for certificates to practise dentistry will be granted the same upon satisfactory examination.

Sec. 5. The Kentucky State Dental Association shall cause to be kept a book in which shall be registered the names of all persons having certificates to practise dentistry in the State of Kentucky, and the book or books so kept shall be a book or books of record; and a transcript from the same, certified by the officer who has it in charge, with the seal of said association affixed thereto, shall be evidence in any court in this Commonwealth.

Sec. 6. Three members of said board of examiners shall constitute a quorum for the transaction of business; and should a quorum not be present on the day appointed for their meeting, those present may adjourn from day to day until a quorum is present.

Sec. 7. Any person who shall, in violation of this act, practise dentistry in the State of Kentucky for a fee or reward shall be liable to indictment by the grand jury of the county in which the offence is committed, and upon conviction shall be fined in the penal sum of not less than fifty nor more than two hundred dollars for each offence; *provided*, That nothing in this act shall be construed to prevent physicians or surgeons from extracting teeth.

Sec. 8. On the trial of indictments found as aforesaid it shall be incumbent on the defendant to show that he has authority under the law to practise dentistry, to exempt himself from the penalty by law prescribed.

Sec. 9. All fines collected under this act shall inure to the benefit of common-school education, and be added to the fund of such common schools in the county in which the offence is committed.

Sec. 10. In order to provide a fund to carry out the provisions in the third section of this act, it shall be the duty of the board of examiners to collect from all who receive the certificate to practise dentistry a sum not to exceed twenty (20) dollars each; of which sum, if there be any remaining after paying necessary expenses, the balance shall be paid into the treasury of said Kentucky State Dental Association, to be kept as a fund for the purpose of carrying out more fully and perfectly the provisions of this act.

Sec. 11. The board of examiners shall receive such remuneration for their services as the by-laws of said Kentucky Dental Association may provide.

Sec. 12. This act shall take effect and be in force from and after its passage.

Approved February 6, 1868.

LOUISIANA.—*An Act to Regulate the Practice of Dentistry in the State of Louisiana.*

Section 1. Be it enacted by the General Assembly of the State of Louisiana, That from and after the passage of this act it shall be unlawful for any person to practise dentistry in the State of Louisiana unless said person has graduated and received a diploma from the faculty of a dental college chartered under the authority of some one of the United States or of some foreign government, or shall have obtained a certificate from a board of examining dentists duly authorized by this act to issue such certificates.

Sec. 2. Be it further enacted, etc., That the board of examining dentists shall consist of five dental graduates, practitioners of dentistry, who are members in good standing of the Louisiana State Dental Society, and have been practising in the State of Louisiana for a term of not less than three years. Said board shall be elected by the State Dental Society to serve for two years. The president of the said Louisiana State Dental Society shall have power to fill all vacancies in said board for unexpired terms.

Sec. 3. Be it further enacted, etc., That it shall be the duty of this board —*first*, to meet annually at the time of meeting of the Louisiana State Dental Society, or oftener at the call of any three members of the said board, and after thirty days' notice thereof; *secondly*, to grant a certificate to any applicant who shall furnish satisfactory evidence of having graduated or received a diploma from any incorporated dental college, without fee, charge, or examination; *thirdly*, to grant certificates to all other applicants who may undergo a satisfactory examination, also without fee or charge of any kind; *fourthly*, to keep a book in which shall be registered the names of all persons to whom such certificates shall be granted.

Sec. 4. Be it further enacted, etc., That the book so kept shall be a book of record, and a transcript from it, certified to by the officer who has it in keeping, shall be evidence in any court of this State.

Sec. 5. Be it further enacted, etc., That three members of said board shall constitute a quorum for the transaction of business; and should a quorum not be present on the day of meeting, those present may adjourn from day to day until a quorum be present.

Sec. 6. Be it further enacted, etc., That two members of said board may grant a certificate to any applicant to practise until the next authorized meeting of the board, when they shall report the fact, and such temporary certificate shall expire; but *such temporary certificate* shall not be granted after the board shall have refused a certificate.

Sec. 7. Be it further enacted, etc., That any person who shall, in violation of this act, pretending to be a regular practitioner of dentistry, practise dentistry in the State of Louisiana, shall be liable to indictment, and on conviction shall be fined not less than fifty nor more than three hundred dollars; *provided*, That nothing in this act shall apply to regular physicians and surgeons.

Sec. 8. Be it further enacted, etc., That one-half of all fines collected shall inure to the Louisiana State Dental Society, and the other half to the educational fund of the parish in which the offence is committed.

Sec. 9. Be it further enacted, etc., That dentists who are in practice in this State at the time of the passage of this act shall be exempt from the provisions made in the first section thereof.

Sec. 10. Be it further enacted, etc., That all laws and parts of laws in conflict with the provisions of this act be and the same are hereby repealed.

Approved March 10, 1880.

MARYLAND.—The following is an act to provide for the better education of dentists and to regulate the practice of dentistry in the State of Maryland:

Section 1. Be it enacted by the General Assembly of Maryland, That it shall be unlawful for any person who is not, at the time of the passage of this act, engaged in the practice of dentistry in this State, to practise dentistry unless he or she shall have obtained a certificate as hereinafter provided, or shall hold a diploma from a university or college chartered by or under the laws of this State authorized to grant diplomas in dental surgery.

Sec. 2. Be it enacted, That a board of examiners, to consist of five reputable practising dentists, is hereby created, whose duty it shall be to carry out the purposes and enforce the provisions of this act; the members of said board shall be appointed by the governor, who shall select them from the dentists residing in this State; *provided,* That none of said board shall be pecuniarily connected with any dental college or dental department of any college or university. The term for which the members of said board shall hold their offices shall be for four years, except that two members of the board, first to be appointed under this act, shall be designated by the governor to hold their offices for the term of two, and three for four years, respectively, unless sooner removed by the governor, and until their successors shall be duly appointed; in case of a vacancy occurring in such board such vacancy shall be filled in like manner by the governor.

Sec. 3. Be it enacted, That said board shall choose one of its members president and one secretary thereof; it shall fix the time and place of its meeting or meetings; a majority of said board shall at all times constitute a quorum, and the proceedings thereof shall at all reasonable times be open to public inspection; the board shall also make an annual report of its proceedings to the governor.

Sec. 4. Be it enacted, That within six months from the time this act takes effect it shall be the duty of every person who is at that time engaged in the practice of denistry in this State to cause his or her name and residence or place of business to be registered with said board of examiners, who shall keep a book for that purpose; the statement of every such person shall be verified under oath before a notary public or justice of the peace in such a manner as may be prescribed by the said board of examiners; every person who shall so register with said board as a practitioner of dentistry may continue to practise the same as such, and shall receive a certificate of such registration upon his or her paying the said board one dollar for such certificate.

Sec. 5. Be it enacted, That any and all persons who shall desire to commence such practice may appear before said board at any of its regular meetings, and be examined with reference to their knowledge and skill in dental surgery; and if the examination of any such person or persons shall prove satisfactory to said board, the board of examiners shall issue to such persons as they shall find to possess the requisite qualifications a certificate to that effect, in accordance with the provisions of this act, upon the payment of one dollar for such certificate; all certificates issued by said board shall be signed by its officers, and such certificates and diplomas, granted as aforesaid, shall be *primâ-facie* evidence of the right of the holder to practise dentistry in the State of Maryland.

Sec. 6. Be it enacted, That any person who shall wilfully violate any of the provisions of this act shall be deemed guilty of a misdemeanor, and

upon conviction thereof in any court having criminal jurisdiction may be fined not less than fifty dollars nor more than three hundred dollars, or be confined not more than six months in the county jail, in the discretion of the court; all fines received under this act shall be paid into the common-school fund of the city or county in which such conviction takes place.

Sec. 7. Be it enacted, That one member of said board may grant any certificate provided for in this act to any applicant, upon presentation by such applicant of the evidence requisite for the obtaining said certificate; which certificate shall remain in force until the next regular meeting of the said board after the granting of said certificate and no longer; but no such certificate shall be issued by such member after such applicant has been rejected by said board.

Sec. 8. Be it enacted, That nothing in this act shall be so construed as to interfere with the rights and privileges of physicians and surgeons in the discharge of their professional duties.

Sec. 9. Be it enacted, That this act shall take effect from the date of its passage.

The Legislature of 1886 repealed Sections 1 and 8 of the law of 1884, and enacted the following:

Be it enacted by the General Assembly of Maryland: That Sections 1 and 8 of the act passed at the January session, eighteen hundred and eighty-four, entitled "An act to ensure the better education of practitioners of dental surgery, and to regulate the practice of dentistry in the State of Maryland," be and the same are hereby repealed and re-enacted, so as to read as follows:

Section 1. That it shall be unlawful for any person who is not at the time of the passage of this act engaged in the practice of dentistry to practise dentistry unless he or she shall have obtained a certificate as herein provided, or shall hold a diploma from a university or college authorized to grant diplomas in dental surgery; any person holding such a diploma and desiring to commence such practice shall present the same to the board of examiners created by this act for approval; such examining board, being satisfied as to the qualifications of the applicant and the genuineness of the diploma, shall indorse the same as approved, and issue the certificate of registration provided for in this act.

Sec. 8. That nothing shall be so construed as to interfere with the rights and privileges of resident physicians and surgeons in the discharge of their professional duties.

Michigan.—The following is the text of a bill to regulate the practice of dentistry in the State of Michigan.

The People of the State of Michigan enact:

Section 1. That it shall hereafter be unlawful for any person to practise dentistry in this State unless such person has received a diploma from the faculty of a reputable dental college duly incorporated under the laws of this or some other State of the United States, or a certificate of qualification from the board of examiners provided for by this act; *provided,* That the provisions of this section shall in no way apply to or affect any person who is now located and in actual practice in this State.

Sec. 2. Said board of examiners shall be appointed by the governor of this State, and shall consist of three practical dentists, who shall be regular

graduates of a reputable dental college duly incorporated under the laws of this or some other State of the United States, or otherwise possess the necessary qualifications contemplated by this act.

Sec. 3. Each member of this board of examiners shall serve for a term of three years, and until his successor is duly appointed and qualified, except in case of the first board; the members thereof shall serve respectively one, two, and three years, as specified in the appointment of the governor.

Sec. 4. The board of examiners shall be organized as follows: The member having but one year to serve shall be president of the board, the one having two years shall be treasurer, and the one having three years shall be secretary. The treasurer shall make and file with the Secretary of State a good and sufficient bond to the people of the State of Michigan in the penal sum of one thousand dollars, conditioned that he will well and truly pay over all moneys received by him as such treasurer in compliance with the provisions of this act, and otherwise faithfully discharge the duties of his office.

Sec. 5. The board of examiners shall meet at least once in each year for the purpose of examining applicants after having given personally or by mail thirty days' written or printed notice to each practising dentist in the State who has filed his name and post-office address with the secretary of said board. The said board is authorized to incur all necessary expenses in the prompt and efficient discharge of its duties, and pay the same with any moneys in the hands of its treasurer.

Sec. 6. Each member of said board shall qualify by taking the oath of office prescribed by the constitution of this State, and filing the same with the Secretary of State before entering upon the duties of his office. Should a vacancy occur in said board the governor of this State shall fill the same by appointment.

Sec. 7. Any member of said board of examiners may, when the board is not in session, examine applicants, and in case any applicant is found competent grant a license to him to practise dentistry in this State until the next meeting of the said board, and no longer, upon the payment of the sum of three dollars; *provided,* No member of the said board shall grant a license to one who has been rejected on an examination by the board.

Sec. 8. Should any member of said board be unable to attend at the meeting of the board for the examination of applicants, he may appoint in writing a substitute, who shall have the same power on the examination that the member appointing him would have if present; *provided,* Such substitute be a person eligible to be a member of said board within the provisions of this act; *and provided further,* That the appointment of such substitute be by and with the written consent of the other members of the board.

Sec. 9. Each applicant shall, on receipt of a license to practise, pay into the treasury of the board the sum of ten dollars, which shall constitute a fund to defray the expenses of the board; and each member of the board shall receive therefrom the sum of three dollars per day for services rendered as such examiner. The said board shall keep a list of the names of all persons to whom licenses have been granted under the provisions of this act, and also of all persons practising dentistry in this State, in a book provided for that purpose, with the names arranged in alphabetical order.

Sec. 10. Any sum in excess of one hundred dollars which, under the provisions of this act, may accumulate in the treasury of said board shall be paid by the treasurer thereof into the treasury of this State.

Sec. 11. Each person now engaged in the practice of dentistry in this

State shall within ninety days after this act takes effect send an affidavit to the secretary of said board setting forth his name, place of business, post-office address, the length of time he has been engaged in practice in this State, and if a graduate of a dental college state the name of the same, and also pay to the treasurer of said board the sum of twenty-five cents; and on failure to comply with the provisions of this section he shall be required to appear and be examined by said board.

Sec. 12. Any person who shall practise dentistry in this State in violation of the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined not less than twenty-five dollars nor more than one hundred dollars, or be sentenced to imprisonment in the county jail for a period not exceeding ninety days, or both such fine and imprisonment in the discretion of the court; *provided,* That nothing in this act shall be construed so as to interfere with physicians and surgeons in their practice as such.

MISSISSIPPI.—The following is the text of "An Act to Regulate the Practice of Dentistry in the State of Mississippi:"

Section 1. Be it enacted, by the Legislature of the State of Mississippi, That it shall be unlawful for any person who is not, at the time of the passage of this act, engaged in the practice of dentistry to begin such practice unless such person shall have received a diploma from the faculty of some reputable dental college duly authorized by the laws of this State or some other of the United States, or of some foreign country, in which college granting such diploma there was at the time of such granting annually delivered a full course of lectures and instructions in dental surgery, unless such person shall comply with the other provisions of this act; *provided, however,* That the provisions of this act shall not apply to any person holding the diploma of doctor of medicine from any reputable medical college; *and provided further,* That nothing in this act shall be so construed as to prohibit any person from extracting teeth.

Sec. 2. Be it further enacted, That a board of dental examiners, consisting of five practising dentists, be hereby created, whose duty it shall be to carry out the purposes and enforce the provisions of this act. The members of said board of dental examiners shall be appointed and commissioned by the governor of this State. Their terms of office shall be for five years, excepting that the members of the board of examiners first appointed shall serve for one, two, three, four, and five years respectively, as designated by the governor, until their respective successors shall be duly appointed and commissioned. All vacancies occurring in the said board of examiners may be filled by the governor at any time.

Sec. 3. Be it further enacted, That said board of dental examiners shall elect one of their number president and one the secretary thereof, and shall meet at the State capital, always giving thirty days' previous notice of such meetings by publication in some newspaper printed and published in the city of Jackson. A majority of said board shall constitute a quorum. Full minutes of their proceedings shall be kept, which shall always be subject to public inspection as any other public records.

Sec. 4. Be it further enacted, That every person engaged in the practice of dentistry in this State shall, within ninety days from the date of approval of this act, cause his or her name and residence or place of business to be registered with said board of examiners, who shall keep a suitable book for that purpose; and every person who shall be so registered may continue

the practice of dentistry in this State without incurring the penalties provided for in this act.

Sec. 5. Be it further enacted, That any person now engaged in the practice of dentistry in this State, failing to register as provided for in Section 4 of this act, shall not be permitted to continue such practice until such person shall have been examined by said board of examiners and regularly licensed in accordance with the provisions of this act.

Sec. 6. Be it further enacted, That if the said board of examiners shall wilfully fail or refuse to register any name presented to them within the time and in pursuance of Section 4 of this act, and issue a certificate to such persons, the members of said board of examiners so failing or refusing shall be held guilty of a misdemeanor, and upon conviction be punished accordingly.

Sec. 7. Be it further enacted, That any person of lawful age and good moral character may appear before said board of examiners at any of its meetings, regular or called, and be examined touching such applicant's knowledge, skill, and proficiency in dental surgery; and upon such examination proving satisfactory said board of examiners shall issue a license, signed by the president and countersigned by the secretary, to such applicant to practise dentistry in this State, and such license shall be impressed with the seal of Mississippi State Dental Association. Any graduate of any reputable dental college may obtain at any time, without examination, such license upon presentation of diploma and the payment of a fee of two dollars to said board of examiners.

Sec. 8. Be it further enacted, That any member of said board of examiners may issue a temporary license to any applicant after a satisfactory examination touching the skill and proficiency of the applicant, the license to remain effective only until the next regular meeting of the board; *provided,* That no such temporary license shall be granted to any applicant who has been rejected by the board of examiners.

Sec. 9. Be it further enacted, That said board of examiners may charge and collect from any person appearing before them for examination for license to practise dentistry a fee of five dollars, and for every license issued to graduates from dental colleges a fee of two dollars, as hereinbefore provided; and all such fees shall be paid over into the treasury of the Mississippi State Dental Association. Out of the fund thus created said board of examiners may receive such compensation as may be fixed by said State Dental Association, subject to be changed from time to time as said association may determine. But no part of such compensation or any of such expenses shall ever be paid out of the State treasury.

Sec. 10. Be it further enacted, That any person licensed by said board of examiners shall, before beginning to practise dentistry, pay the privilege tax which may be required by the general statutes of this State, and have his license from the said board of examiners recorded in the deed records of every county in which he may desire to practise his profession.

Sec. 11. Be it further enacted, That any violation of the provisions of this act shall be a misdemeanor and punishable as such, the fine in no case being less than ten dollars.

Sec. 12. Be it further enacted, That this act take effect from and after its passage.

Approved February 25, 1882.

MISSOURI.—The following is the text of an act to regulate the practice of dentistry in the State of Missouri. This act differs from all

others in force of which we have knowledge in that it requires the possession of a diploma from all who hereafter engage in the practice of dentistry in the State. This requirement does not, of course, apply to *bonâ-fide* practitioners within the State at the date of its enactment.

Be it enacted by the General Assembly of the State of Missouri, as follows:

Section 1. It shall be unlawful for any person to practise dentistry or dental surgery in the State of Missouri without first having received a diploma from a reputable dental college or a university duly incorporated or established under the laws of some one of the United States or of a foreign government; *provided,* That nothing in Section 1 of this act shall apply to any *bonâ-fide* practitioner of dentistry or dental surgery in this State at the time of the passage of this act; *and provided,* That nothing in this act shall be so construed as to prevent physicians, surgeons, or others from extracting teeth.

Sec. 2. Every person who shall hereafter engage in the practice of dentistry or dental surgery in this State shall file a copy of his diploma with the clerk of the county court in the county in which he resides, and in the city of St. Louis with the city register, which copy shall be sworn to by the party filing the same, and the clerk shall give a certificate of such fact, with the seal of the county court attached thereto, to such party filing the copy of his diploma, and shall file and register the name of the person, the date of filing, and the nature of the instrument in a book to be kept by him for that purpose; and as a compensation for his services the said clerk for filing and registering the same shall receive a fee of one dollar, to be paid by the person filing the diploma.

Sec. 3. Every *bonâ-fide* practitioner of dentistry or dental surgery residing in this State at the time of the passage of this act and desiring to continue the same shall, within ninety days after the passage of this act, file an affidavit of the said facts with the clerk of the county court of the county in which he resides, or with the city register of the city of St. Louis if he resides in the city of St. Louis; and the said clerk or register, as the case may be, shall register the name of, and give a certificate to, the party filing the affidavit, in like manner and of like effect as hereinbefore provided, and for such services shall receive a fee of one dollar, to be paid by the party filing the affidavit.

Sec. 4. All certificates issued under the provisions of this act shall be *primâ-facie* evidence of the right of the holder to practise under this act; which right it shall be incumbent upon the holder to prove under all prosecutions under this act.

Sec. 5. Every person violating any of the provisions of this act shall upon conviction thereof be deemed guilty of a misdemeanor, and be punished by a fine of not less than twenty-five nor more than two hundred dollars for each offence; and all fines so collected shall belong to and be paid into the common-school fund of the county where the offence was committed.

New Hampshire.—The following are sections of the general laws of the State of New Hampshire relating to the practice of dentistry:

Cap. 1, Section 3. It shall not be lawful for any person who is not duly authorized to practise medicine or surgery to practise dentistry, unless such person has received a dental degree from some college, university, or med-

ical school authorized to confer the same, or shall have obtained a license from the New Hampshire Dental Society.

Sec. 4. Said dental society shall, at such time and in such manner as may be prescribed in its charter or by-laws, elect a board of censors consisting of three members, who shall be elected for such term as may be prescribed by the society; which board shall have authority to examine and license persons to practise dentistry. The license shall be recorded by the clerk of said society.

Sec. 5. No person receiving a license as herein provided shall be authorized to practise until he shall have procured the same to be recorded by the clerk of the court in the county where he resides, if a resident of this State; if not a resident of this State, in the county where he intends to practise. Such license shall be recorded in a book provided for that purpose, and which shall bear the title and inscription of the medical and dental register of ——— county, and the fee for recording the same shall be fifty cents.

Sec. 6. Each person receiving a license upon examination shall pay for the use of the society granting the same the sum of five dollars; upon diploma, one dollar.

Sec. 7. If any person shall practise medicine, surgery, midwifery, *or dentistry* without being duly authorized as provided in this chapter, or after his license is revoked, he shall be punished by a fine of not more than three hundred dollars for each offence.

NEW JERSEY.—*An Act to Regulate the Practice of Dentistry, and to Protect the People against Empiricism in Relation thereto, in the State of New Jersey.*

1. Be it enacted by the Senate and General Assembly of the State of New Jersey, That from and after the passage of this act it shall be unlawful for any person to engage in the practice of dentistry in the State of New Jersey unless said person has graduated and received a diploma from the faculty of a dental college chartered under the authority of some one of the United States or foreign governments, or shall have obtained a certificate from a board of dentists duly authorized and appointed by this act to issue such certificates.

2. And be it enacted, That the board of examiners shall consist of five practitioners of dentistry who are members in good standing of the New Jersey State Dental Society; *provided,* That said practitioners have been practising in the State of New Jersey for a term of not less than three years: said board shall be elected by the New Jersey State Dental Society to serve for one year; the president of said New Jersey Dental Society shall have power to fill all vacancies in said board for unexpired terms.

3. And be it enacted, That it shall be the duty of this board—first, to meet annually at the time of meeting of the New Jersey State Dental Society, or oftener at the call of any three of the members of said board: thirty days' notice must be given of the annual meetings; secondly, to prescribe a course of reading for those who study dentistry under private instruction; thirdly, to grant a certificate to all applicants who undergo a satisfactory examination; fourthly, to keep a book in which shall be registered the names of all persons having certificates to practise dentistry in the State of New Jersey after the passage of this act.

4. And be it enacted, That the book so kept shall be a book of record;

and a transcript from it, certified to by the officer who has it in keeping, with the common seal, shall be evidence in any court in the State.

5. And be it enacted, That three members of said board shall constitute a quorum for the transaction of business; and should a quorum not be present on the day appointed for their meeting, those present may adjourn from day to day until a quorum is present.

6. And be it enacted, That any person who shall, in violation of this act, practise dentistry in the State of New Jersey for a fee or reward shall be liable to indictment, and on conviction shall be fined not less than fifty or more than three hundred dollars; *provided,* That nothing in this act shall be construed to prevent any person from extracting teeth; *and provided further*, That none of the provisions of this act shall apply to regular licensed physicians and surgeons.

7. And be it enacted, That on trial of such indictment it shall be incumbent on the defendant to show that he has authority under the law to practise dentistry, to exempt himself from such penalty.

8. And be it enacted, That one half of all fines collected shall inure to the informer, and the other half to the educational fund of the county.

9. And be it enacted, That nothing in this act shall apply to persons who shall be engaged in the practice of dentistry in this State at the time of the passage of this act.

10. And be it enacted, That to provide a fund to carry out the provisions of the third section of this act, it shall be the duty of the board of examiners to collect from all who receive the certificate to practise dentistry the sum of thirty dollars each; of which sum, if there be any remaining after liquidating necessary expenses, the balance shall be paid into the treasury of the said New Jersey State Dental Society, to be kept as a fund for the more perfect carrying out of the provisions of this act; and the board of examiners for their remuneration shall receive from the above fund ten dollars per day for each day of actual service.

11. And be it enacted, That this act shall take effect immediately.

Approved March 14, 1873.

The following amendment to the dental law of New Jersey has been passed by the Legislature and signed by the governor of that State:

A Supplement to an Act entitled "An Act to Regulate the Practice of Dentistry and to Protect the People against Empiricism in Relation thereto, in the State of New Jersey," approved March fourteenth, one thousand eight hundred and seventy-three.

1. Be it enacted by the Senate and General Assembly of the State of New Jersey, That the first section of the act to which this is a supplement shall be amended so as to read as follows:

[*1.* Be it enacted by the Senate and General Assembly of the State of New Jersey, That from and after the passage of this act it shall be unlawful for any person not now lawfully practising to engage in the practice of dentistry in the State of New Jersey, unless said person has graduated and received a diploma from the faculty of a reputable dental college chartered under the authority of some one of the United States; and that any person hereafter engaging in the practice of dentistry in the State shall, within one month after commencing such practice, register his name in a book kept for that purpose in the county clerk's office of the county in which he shall have engaged in the practice of dentistry, giving his name and the name of the dental college of which he is a graduate, and the name of the place in which

he shall have engaged in practice; and for which registry the said county clerk shall be entitled to demand and receive from each person registering the sum of fifty cents; and any person violating any of the provisions of this act shall be liable to the penalties prescribed in the sixth section of the act to which this is a supplement.]

The following supplement to an act entitled "An Act to Regulate the Practice of Dentistry, and to Protect the People against Empiricism in Relation thereto, in the State of New Jersey," was passed February 10, 1880:

1. Be it enacted by the Senate and General Assembly of the State of New Jersey, That from and after the passage of this act it shall be unlawful for any person to engage in the practice of dentistry in the State of New Jersey unless said person has pursued a regular course of instruction for at least one year in a reputable dental college chartered under the authority of some one of the United States or foreign governments, and has graduated and received a diploma from such college, or unless the said person shall have obtained a certificate from a board of dentists duly authorized and appointed by this act to issue such certificate, and shall have registered his name and the name of the said dental college or board of dentists in the county clerk's office of the county in which he shall have engaged in the practice of dentistry, within one month after commencing such practice, in a book to be provided and kept for that purpose in the several county clerks' offices of the several counties of this State; and for which registry the said county clerk shall be entitled to demand and receive from each person registering the sum of fifty cents; and any person violating any of the provisions of this act shall be liable to the penalties prescribed in the sixth section of the act to which this is a supplement.

2. And be it enacted, That this act shall take effect immediately.

NEW YORK.—*An Act to Incorporate Dental Societies for the Purpose of Improving and Regulating the Practice of Dentistry in this State.*

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. It shall be lawful for the dentists in the several judicial districts of the supreme court of this State to meet together at the following-named places, to wit: In district No. 1, at the Cooper Institute in the city of New York; district No. 2, at the City Hall in the city of Brooklyn; district No. 3, at the Delavan House in the city of Albany; district No. 4, at the Clarendon Hotel, Saratoga Springs; district No. 5, at the Stanwix Hall Hotel in the village of Rome; district No. 6, at the Lewis House in the village of Binghamton; district No. 7, at the Canandaigua Hotel in the village of Canandaigua; district No. 8, at the Medical Hall in the city of Buffalo,—on the first Tuesday of June, eighteen hundred and sixty-eight, at two o'clock in the afternoon of that day; and such dentists so convened as aforesaid, or any part of them not less than fifteen in number, shall proceed to the choice of a president, vice-president, secretary, and treasurer, who shall hold their offices for one year and until others shall be chosen in their places; and whenever said societies shall be organized as aforesaid they are hereby constituted bodies corporate in fact and under the names of the "District Dental Society" of the respective judicial districts where they shall be located; *provided always*, That if the dentists

residing in any district shall not meet and organize themselves as aforesaid, it shall be lawful for them, at the call of fifteen dentists residing in such district, to meet at such other time and place as they shall designate, and their proceedings shall be as valid as if such meeting had been at the time before specified.

Sec. 2. Each of said district societies when organized as aforesaid shall elect eight delegates, who shall meet at the Capitol in the city of Albany on the last Tuesday of June, eighteen hundred and sixty-eight, and proceed to organize a State dental society, which shall be named "The Dental Society of the State of New York," and, being met, not less than thirty-three in number, shall proceed to elect, and shall thereafter annually elect, a president, vice-president, secretary, and treasurer, who shall hold their offices for one year and until others shall be chosen in their places; and said society shall be a body corporate under the name and style as aforesaid.

Sec. 3. The secretaries of each of the district societies shall lodge in the county clerk's office of some county within their district a copy of all the proceedings and records of their organization; and it shall also be the duty of the secretary of the State Dental Society in like manner to lodge in the office of the Secretary of State a copy of its records and proceedings had at the organization thereof; and the said county clerks respectively and the Secretary of State shall file the same in their respective offices, and shall receive therefor a fee of ——.

Sec. 4. At the first meeting of said State Dental Society, the same being duly organized as aforesaid, the delegation from each district society shall be divided into four classes of two delegates each, who shall serve one, two, three, and four years respectively, and until others shall be elected in their places; and the said district societies at each annual meeting thereafter shall choose two delegates to the State society, to serve each four years, and fill all vacancies in their respective delegations that may have occurred by death or otherwise.

Sec. 5. Each of the incorporated dental colleges of this State may annually elect two delegates to the State Dental Society, who shall be entitled to all the privileges and subject to the same rules and regulations as other delegates.

Sec. 6. The said State Dental Society may elect permanent members of said society from among eminent dentists residing in this State, but not to exceed twenty in number, at its first meeting, nor more than five in any one year thereafter; which members, so elected, shall be entitled to all the privileges of delegate members, but shall receive no compensation for their attendance on meetings of the State society, except when sent as delegates by the district societies or colleges as aforesaid. And the said State society may elect honorary members from any State or country; but no person shall be elected an honorary member who is eligible to regular membership, nor shall any honorary member be entitled to vote or hold any office in said society.

Sec. 7. The several district societies established as aforesaid at their annual meetings shall appoint not less than three nor more than five censors, to continue in office for one year and until others are chosen, who shall constitute a district board of censors, whose duty it shall be carefully and impartially to inquire into the qualifications of all persons who shall present themselves within the districts where they reside for examination, and report their opinion, in writing, to the president of said district society, who shall thereupon issue, on the recommendation of said board of censors,

a certificate of qualification to such person or persons, countersigned by the secretary and bearing the seal of the said district society.

Sec. 8. The State Dental Society, organized as aforesaid, at its first meeting shall appoint eight censors, one from each of the said district societies, who shall constitute a State board of censors; and at the first meeting of said board the members shall be divided into four classes, to serve one, two, three, and four years respectively; and said State Dental Society shall at each annual meeting thereafter appoint two censors, to serve each four years and until their successors shall be chosen, and fill all vacancies that may have occurred in the board by death or otherwise. Each district society shall be entitled to one, and only one, member of said board of censors. Said board of censors shall meet at least once in each year, at such time and place as they shall designate; and being thus met, they or a majority of them shall carefully and impartially examine all persons who are entitled to examination under the provisions of this act, and who shall present themselves for that purpose, and report their opinion in writing to the president of said State Dental Society; and on the recommendation of said board it shall be the duty of the president aforesaid to issue a diploma to such person or persons, countersigned by the secretary, and bearing the seal of said society.

Sec. 9. All dentists in regular practice at the time of the passage of this act, and all persons who shall have received a diploma from any dental college in this State, and all students who shall have studied and practised dental surgery with some accredited dentist or dentists for the term of four years, shall be entitled to an examination by said board of censors. Deductions from such term of four years shall be made in either of the following cases:

1. If the student after the age of sixteen shall have pursued any of the studies usual in the colleges of this State, the period, not exceeding one year, during which he shall have pursued such studies shall be deducted.

2. If the student after the age of sixteen shall have attended a complete course of lectures of any incorporated dental or medical college in this State or elsewhere, one year shall be deducted.

Sec. 10. Every person on receiving a diploma from the State Dental Society shall pay into the treasury thereof the sum of twenty dollars, and on receiving a certificate of qualification from the dental society of any district, the sum of ten dollars into the treasury thereof.

Sec. 11. The dental societies of the respective districts and the Dental Society of the State may purchase and hold such real and personal estate as the purposes of their respective corporations may require—the district societies each not exceeding in value the sum of five thousand dollars, and the State Dental Society not exceeding twenty thousand dollars in value.

Sec. 12. The respective societies herein provided for may make all needful by-laws, rules, and regulations, not inconsistent with any existing law, for the management of the affairs and property of said societies respectively, and providing for the admission and expulsion of members; *provided,* That such by-laws, rules, and regulations of the respective district societies shall not be repugnant to nor inconsistent with the by-laws, rules, and regulations of the State Dental Society.

Sec. 13. All dentists who shall have been in regular practice in this State at the time of the passage of this act, and all persons who shall have received a certificate of qualification from any district society, shall be eligible to membership in said district societies.

Sec. 14. The Dental Society of the State of New York shall be entitled

to all the privileges and immunities granted to the medical societies of this State.

Sec. 15. This act shall take effect immediately.

Approved April 7, 1868.

An Act to Amend an Act entitled "An Act to Incorporate Dental Societies, for the Purpose of Improving and Regulating the Practice of Dentistry in this State."

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. Section 8 of the act entitled "An Act to Incorporate Dental Societies, for the Purpose of Improving and Regulating the Practice of Dentistry in this State," is hereby amended so as to read as follows:

Sec. 8. The State Dental Society, organized as aforesaid, at its first meeting shall appoint eight censors, one from each of the said district societies, who shall constitute a State board of censors; and at the first meeting of the said board the members shall be divided into four classes, to serve one, two, three, and four years respectively; and said State Dental Society shall, at each annual meeting thereafter, appoint two censors, to serve each four years and until their successors shall be chosen, and fill all vacancies that may have occurred in the board by death or otherwise. Each district Society shall be entitled to one, and only one, member of said board of censors. Said board of censors shall meet at least once in each year, at such time and place as they shall designate; and, being thus met, they or a majority of them shall carefully and impartially examine all persons who are entitled to examination under the provisions of this act, and who shall present themselves for that purpose, and report their opinion in writing to the president of said State Dental Society; and on the recommendation of the said board it shall be the duty of the president aforesaid to issue a diploma to such person or persons, countersigned by the secretary and bearing the seal of said society, conferring upon him the degree of "Master of Dental Surgery" (M. D. S.); and it shall not be lawful for any other society, college, or corporation to grant to any person the said degree of "Master of Dental Surgery."

Sec. 2. Any person who shall knowingly or falsely claim or pretend to have or hold a certificate of license, diploma, or degree granted by any society organized under and pursuant to the provisions of this act, or who shall falsely and with intent to deceive the public claim or pretend to be a graduate from any incorporated dental college, not being such graduate, shall be deemed guilty of a misdemeanor.

Sec. 3. This act shall take effect immediately.

The following act is additional to legislation already had on the subject in the State of New York:

An Act for the Relief of Certain Persons Engaged in the Regular Practice of Dentistry in this State.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. Any person who was engaged in the regular practice of dentistry within this State on the twentieth day of June, eighteen hundred and seventy-nine, and who was entitled to registration as a dentist, as provided

by the third section of chapter five hundred and forty of the laws of eighteen hundred and seventy-nine, entitled "An Act to Regulate the Practice of Dentistry in the State of New York," but who failed to cause his name to be registered as therein provided, and who shall make and file with the clerk of the county in which he registers his affidavit to the effect that he was so engaged in such practice of dentistry and so entitled to registration, may, within sixty days after the passage of this act, cause his name, office, and post-office address to be registered in the county clerk's office in the manner provided in said third section of said act; and such registration shall have like force and effect as if made within the time prescribed by said section of said act. Any person who shall wilfully make and file a false affidavit for the purpose of procuring such registration shall be subject to conviction and punishment for perjury.

Sec. 2. Every person hereafter authorized to practise dentistry within this State shall, before commencing to practise, register in the clerk's office of the county where he intends to commence the practice of dentistry, in a book to be kept for that purpose, his name, office, and post-office address, together with the name of the society, college, or other authority from which he has received his diploma or certificate of qualification to practise dentistry.

Sec. 3. The clerk of any county shall be obliged, upon the payment to him of the sum of twenty-five cents, to make the registry of any person provided for in the second section of this act, which sum the clerk is entitled to collect and receive from the person registering.

Sec. 4. This act shall take effect immediately.

NORTH CAROLINA.—*An Act to Regulate the Practice of Dentistry and to Protect the People against Quackery in Relation thereto, in the State of North Carolina, and Providing Penalties for the Violation of the Same.*

The General Assembly of North Carolina do enact:

Section 1. That from and after the ratification of this act it shall be unlawful for any person except regularly authorized physicians and surgeons to commence the practice of dentistry in the State of North Carolina, unless said person has graduated and received a diploma from the faculty of a reputable institution where this specialty is taught, and chartered under the authority of some one of the United States or of a foreign government, acknowledged as such, or shall have obtained a certificate from a board of examiners duly appointed and authorized by the provisions of this act to issue such certificate.

Sec. 2. That the said board of examiners hereinbefore provided for shall consist of six members of the North Carolina Dental Society, to be elected by the said society at its next annual meeting, and shall hold office as follows: two for one year, two for two years, and two for three years, or until their successors are elected. The said board shall also have power to fill all vacancies for unexpired terms, and they shall be responsible to said State Dental Society for their acts.

Sec. 3. That the board of examiners shall meet annually at the time and place of the meeting of the North Carolina Dental Society, and at such other times and places as the said board or any four members thereof shall agree upon, to conduct the examination of applicants, thirty days' notice of said meeting being given by advertising in at least three newspapers published in this State.

Sec. 4. The said board shall grant a certificate of proficiency in the

knowledge and practice of dentistry to all applicants who shall undergo a satisfactory examination, and who shall receive a majority of votes of said board upon such proficiency; which certificate shall be signed by the members of the board conducting said examination, and shall bear the seal of the said North Carolina Dental Society; *provided,* That any person wishing to engage in the practice of dentistry at any time prior to the regular meeting of said board may be examined by any one member of said board, and if competent may receive a temporary certificate, which shall be in force only until the next regular meeting; and no member of said board shall grant a temporary certificate a second time to the same person.

Sec. 5. That said board shall keep a book in which shall be entered the names and proficiency of all persons to whom certificates shall be granted under the provisions of this act, and the date of granting said certificate; and the book so provided for shall be deemed a book of record, and a transcript of any such entry therein, certified to under the hand of the secretary and seal of the North Carolina Dental Society, shall be admitted as evidence in any court of this State where the same shall be otherwise competent.

Sec. 6. That four members of said board shall constitute a quorum thereof for the transaction of business; and should a quorum not be present on the day appointed for the meeting of said board, those present may adjourn from day to day until a quorum is present.

Sec. 7. That any person that shall practise dentistry in this State without having first stood the examination and obtained the certificate hereinbefore provided for shall be deemed guilty of a misdemeanor, and upon conviction shall be fined twenty-five (25) dollars; *provided,* That any person so convicted shall not be entitled to sue for or to recover any fee or charge for dental service in any court of this State, and [any] sum or sums of money paid to [a] person so convicted for dental services rendered may be recovered by the person so paying the same or his or her legal representative; *provided,* That no one applying for a license to practise dentistry shall be denied such license on account of race, color, or previous condition of servitude.

Sec. 8. That all fines and penalties so recovered shall be appropriated to the school fund of the county in which the same shall have been recovered.

Sec. 9. That nothing in this act shall apply to any person engaged in the practice of dentistry at the date of the ratification of the same, nor to prevent any one from extracting teeth.

Ratified the 7th day of March, A. D. 1879.

OHIO.—*A Law to Regulate the Practice of Dentistry in the State of Ohio.*

Section 1. Be it enacted by the General Assembly of the State of Ohio, That it shall be unlawful for any person to practise dentistry in the State of Ohio for compensation, unless such person has received a diploma from the faculty of a dental college duly incorporated under the laws of this or any other State of the United States or foreign country, or a certificate of qualification issued by the State Dental Society or by any local society auxiliary thereto; *provided,* That nothing in this section shall apply to persons now engaged in the practice of dentistry in this State before the first day of January, 1873.

Sec. 2. Any person who shall practise dentistry without having complied with the regulations of this act shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined not less than fifty or more than

two hundred dollars; *provided*, That nothing in this act shall be construed to prevent physicians and surgeons from extracting teeth.

Sec. 3. All prosecutions under this act shall be by indictment before the court of common pleas in the county where the offence was committed, and all fines imposed and collected under the provisions of this act shall be paid into the treasury of the county where such conviction shall take place, for the use of the common schools within such county.

Sec. 4. This act shall take effect and be in force from and after its passage.

The above act was passed May 8, 1868, but was afterward amended as follows:

An Act to Amend Section 1 of an Act entitled "An Act to Regulate the Practice of Dentistry in the State of Ohio," passed May 8, 1868.

Section 1. Be it enacted by the General Assembly of the State of Ohio, That Section 1 of the above-named act be so amended as to read as follows: That it shall be unlawful for any person to practise dentistry in the State of Ohio for compensation unless such person has received a diploma from the faculty of a dental college duly incorporated under the laws of this or any other State of the United States or foreign country, or a certificate of qualification issued by the State Dental Society; *provided*, That in all cases where any person has been continuously engaged in the practice of dentistry for a period of five years or more, such person shall be considered to have complied with the provisions of this act and the act to which this is amendatory.

Sec. 2. Any person who shall practise dentistry without having complied with the regulations of this act shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined not less than fifty dollars nor more than two hundred dollars; *provided*, That nothing in this act shall be construed to prevent physicians and surgeons from extracting teeth.

Sec. 3. All prosecutions under this act shall be by indictment before the court of common pleas in the county where the offence was committed, and all fines imposed and collected under the provisions of this act shall be paid into the treasury of the county where such conviction shall take place, for the use of the common schools within such county.

Sec. 4. That said original Section 1 be and is hereby repealed.

Sec. 5. This act shall take effect and be in force from and after its passage.

Passed March 10, 1873.

PENNSYLVANIA.—*An Act to Regulate the Practice of Dentistry, and to Protect the People against Empiricism in Relation thereto, in the State of Pennsylvania, and Providing Penalties for the Violation of the Same.*

Section 1. Be it enacted by the Senate and House of Representatives of the Commonwealth of Pennsylvania, in General Assembly met, and it is hereby enacted by the authority of the same, That from and after the passage of this act it shall be unlawful for any person except regularly authorized physicians and surgeons to engage in the practice of dentistry in the State of Pennsylvania, unless said person has graduated and received a diploma from the faculty of a reputable institution where this specialty is taught, and chartered under the authority of some one of the United States or of a foreign government, acknowledged as such, or shall have obtained

a certificate from a board of examiners duly appointed and authorized by the provisions of this act to issue such certificate.

Sec. 2. That the board of examiners shall consist of six practitioners of dentistry who are of acknowledged ability in the profession. Said board shall be elected by the Pennsylvania State Dental Society at their next annual meeting, as follows: Two shall be elected for one year, two for two years, and two for three years, and each year thereafter two shall be elected to serve for three years or until their successors are elected. The said board shall have power to fill all vacancies for unexpired terms, and they shall be responsible to said State Dental Society for their acts.

Sec. 3. That it shall be the duty of this board—

First. To meet annually at the time and place of meeting of the Pennsylvania State Dental Society, and at such other time and place as the said board shall agree upon, to conduct the examination of applicants. They shall also meet for the same purpose at the call of any four members of said board, at such time and place as may be designated. Thirty days' notice must be given of the meetings by advertising in at least three periodicals, one of them being a dental journal, and all published within this State.

Second. To grant a certificate of ability to practise dentistry, which certificate shall be signed by said board and stamped with a suitable seal, to all applicants who undergo a satisfactory examination and who receive at least four affirmative votes.

Third. To keep a book in which shall be registered the names and the qualifications, as far as practicable, of all persons who have been granted certificates of ability to practise dentistry under the provisions of this act.

Sec. 4. That the book so kept shall be a book of record, and a transcript from it, certified to by the officer who has it in keeping, with the seal of said board of examiners, shall be evidence in any court of this State.

Sec. 5. That four members of this board shall constitute a quorum for the transaction of business; and should a quorum not be present on any day appointed for their meeting, those present may adjourn from day to day until a quorum is present.

Sec. 6. That any person who shall in violation of this act practise dentistry in the State of Pennsylvania shall be liable to indictment in the court of quarter sessions of the proper county, and on conviction shall be fined not less than fifty nor more than two hundred dollars; *provided*, That any person so convicted shall not be entitled to any fee for services rendered; and if a fee shall have been paid, the patient or his or her heirs may recover the same as debts of like amount are now recoverable by law.

Sec. 7. That all fines collected shall inure to the poor fund of the county in which the prosecution occurs.

Sec. 8. That nothing in this act shall apply to persons who shall have been engaged in the continuous practice of dentistry in this State for three years or over at the time of or prior to the passage of this act.

Sec. 9. That to provide a fund to carry out the provisions of the third section of this act it shall be the duty of the said board of examiners to collect from those who receive the certificate to practise dentistry the sum of thirty (30) dollars each, of which sum, if there be any remaining after liquidating necessary expenses, the balance shall be paid into the treasury of the said Pennsylvania State Dental Society, to be kept as a fund for the more perfect carrying out of the provisions of this act.

Signed April 17, 1876.

Supplementary to the foregoing act is the following act in reference to the registration of dentists:

An Act for the Registration of Dentists, supplementary to the Act entitled "An Act to Regulate the Practice of Dentistry, and to Protect the People against Empiricism in Relation thereto, in the State of Pennsylvania, and Providing Penalties for the Same."

Section 1. Be it enacted by the Senate and House of Representatives of the Commonwealth of Pennsylvania in General Assembly met, and it is hereby enacted by the authority of the same, That it shall be the duty of any person practising dentistry within this Commonwealth within three months after the passage of this act, and of any person intending to practise dentistry within this Commonwealth before commencing the same, to have recorded in the recorder's office in the county in which he or she practises or intends to practise the diploma or certificate provided for in the act to which this is a supplement.

Sec. 2. Any person *beginning* to practise dentistry in this State after the passage of this act, having a dental diploma issued or purporting to have been issued by any college, university, society, or association, shall present the same to the State examining board provided for in the act to which this is a supplement for approval; such examining board, being satisfied as to the qualifications of the applicant and the genuineness of the diploma, shall, *without fee*, indorse the same as approved, after which the same may be recorded as aforesaid.

Sec. 3. Any person who is entitled to practise dentistry in this Commonwealth without a diploma or certificate, under the provisions of the eighth section of the act to which this is a supplement, shall make written affidavit before some person qualified to administer an oath, setting forth the time of his continuous practice and the place or places where such practice was pursued in this Commonwealth, and shall within three months after the passage of this act have such affidavit recorded in the recorder's office of the county in which he is practising; and it shall be the duty of the recorder to record such diplomas, certificates, and affidavits in a book provided for such purposes.

Sec. 4. Any person who shall violate or fail to comply with any of the provisions of this act or of the act to which this is a supplement, or who shall cause to be recorded any diploma or certificate which has been obtained fraudulently or is in whole or in part a forgery, or shall make affidavit to any false statement to be recorded as aforesaid, shall be guilty of a misdemeanor, and on conviction shall be sentenced to pay a fine of not less than fifty nor more than two hundred dollars for each offence for the use of the proper county.

Sec. 5. All acts or parts of acts inconsistent herewith are hereby repealed.

Approved April 17, 1886.

South Carolina.—*An Act to Regulate the Practice of Dentistry, and Protect the People against Empiricism in Relation thereto, in the State of South Carolina.*

Be it enacted by the Senate and House of Representatives of the State of South Carolina, now met and sitting in General Assembly, and by the authority of the same:

Section 1. That from and after the passage of this act it shall be unlaw-

ful for any person or persons to engage in the practice of dentistry in the State of South Carolina unless said person or persons shall receive a diploma from the faculty of some dental college, duly incorporated under the laws of this or some other State of the United States or foreign government, in which is annually delivered, in good faith, a full course of lectures and instructions in dentistry, or shall have obtained a license from a board of dentists duly authorized and appointed by this act to issue such license.

Sec. 2. It shall be the duty of the South Carolina State Dental Association, at the next annual meeting thereof after the passage of this act, to elect a board of examiners, to consist of five members, to be known by the title of "The Board of Dental Examiners in the State of South Carolina." The members of this board shall at the first election be elected for terms of one, two, three, four, and five years respectively, or until their successors shall have been elected. And it shall be the duty of the South Carolina State Dental Association, at each subsequent annual meeting thereof, to elect a person for the term of five years to fill the place of the member of the board whose term of office shall at that time expire, and also to fill such vacancies in the board as may have occurred during the year. And if at any regular meeting of the board any member or members shall fail to be present, the South Carolina State Dental Association may, at its discretion, declare the office of such absentee to be vacated, and may proceed to elect a new member or members for the unexpired term of such person or persons, or it may elect a member or members to fill temporarily the place or places of such absentees. This board shall be organized by the election of a president and secretary.

Sec. 3. It shall be the duty of the board of examiners to meet annually at the time and place of meeting of the South Carolina State Dental Association, giving thirty days' notice in the public newspapers published in not less than three different places in the State—viz. one in Charleston, one in Columbia, and one in Greenville—of such annual meeting. Secondly, to prescribe a course of reading for those who study dentistry under private instructions. Thirdly, to grant a license to any applicant who shall furnish satisfactory evidence of having graduated and received a diploma from any incorporated dental college in good standing with the profession, without fee, charge, or examination. Fourthly, to grant license to all applicants who undergo a satisfactory examination. Fifthly, to keep a book in which shall be registered all persons licensed to practise dentistry in the State of South Carolina. The expenses of said license shall be fifteen dollars, to be paid by the licensee. And that any person who does now hold or may hereafter hold a license to practise dentistry in this State shall become a member of the South Carolina State Dental Association immediately upon obtaining said license; *provided,* He shall be allowed to waive his right of membership.

Sec. 4. That the book so kept shall be a book of record, and a transcript from it, certified by the officer who has it in keeping, with the common seal, shall be evidence in any court of the State.

Sec. 5. That three members of said board shall constitute a quorum for the transaction of business; and should a quorum not be present on the day appointed for their meeting, those present may adjourn from day to day until a quorum is present.

Sec. 6. That one member of said board may grant a license to an applicant to practise until the next regular meeting of the board, when he shall report the fact, at which time the temporary license shall expire; but such

temporary license shall not be granted by a member of the board after the board has rejected the applicant.

Sec. 7. That every dentist in this State be required to keep a record of all cases treated in his practice, in accordance with a form to be designated by the South Carolina State Dental Association, and furnish his patient with a copy of the same if so desired by the patient.

Sec. 8. That any person who shall, in violation of this act, practise dentistry in the State of South Carolina for a fee or reward shall be liable to indictment, and on conviction shall be fined not less than fifty or more than three hundred dollars; *provided*, That nothing in this act shall be so construed as to prevent any person from extracting teeth.

Sec. 9. That on trial of such indictment it shall be incumbent on the defendant to show that he has authority under the law to practise dentistry, to exempt himself from such penalty.

Sec. 10. That all fines collected shall inure to the educational fund of the county where the offender resides.

Sec. 11. That those who have been in the regular practice of dentistry in the State prior to the passage of this act are exempt from the provisions of the same, except Section 7 of this act.

Sec. 12. That the South Carolina State Dental Association is hereby made a body politic and corporate, shall have and use a common seal, sue and be sued, plead and be impleaded, and be empowered to make all necessary by-laws not inconsistent with the State laws and Constitution.

Sec. 13. That all acts or parts of acts inconsistent with this act be, and the same are hereby, repealed.

Approved February 23, 1875.

VERMONT.—*An Act Regulating the Practice of Dentistry.*

It is hereby enacted, etc.:

Section 1. There shall be a board of dental examiners. The board shall consist of five dental graduates or practitioners of dentistry, to be appointed by the governor in the month of November, 1882, and in the month of November biennially thereafter. The term of office of members so appointed shall commence on the first day of December following their appointment, and continue for two years and until their successors are appointed. The governor shall fill vacancies in the board.

Sec. 2. The board shall meet annually or oftener. Meetings shall be held on the call of three members. Thirty days' notice of each meeting shall be given by mail to each practising dentist in the State known to the board.

Sec. 3. The board shall at their meetings examine applicants for licenses to practise dentistry, and shall grant a license to each one whom they find qualified on payment to the board by each person of the sum of five dollars. The board shall grant a license without fee to any person who has received a diploma from any incorporated dental college, and to each person residing and engaged in the practice of dentistry within the State at the time of the passage of this act, on application of such person, accompanied by satisfactory proof of the facts which entitle him to such license.

Sec. 4. Any member of the board may, when the board is not in session, grant a license to practise dentistry to a person whom such member finds on examination to be qualified, on the payment of the sum of two dollars by such person. A license so granted shall be valid until the next meeting of the board, but no longer. Each member shall make a report of

licenses so granted by him at the meeting of the board next following the granting of the license. A member shall not grant a license under the provisions of this section to one who has been rejected by the board as unqualified.

Sec. 5. Members of the board shall receive three dollars each a day for time spent in examining applicants and granting licenses if the fees received from applicants during the biennial term in which such services are rendered shall be sufficient therefor; and at the end of each biennial term the board shall file with the State auditor a statement of their receipts and disbursements verified by oath, and shall at the same time pay into the State treasury any excess remaining in their hands.

Sec. 6. A person who without a license in force practises dentistry in this State for a compensation or reward shall be fined not less than twenty-five dollars nor more than one hundred dollars. But no penalty shall attach to a person for merely extracting teeth.

Sec. 7. The board of dental examiners shall keep a book in which they shall cause to be entered the name of each person to whom a license has been issued under the provisions of this act.

Sec. 8. A person receiving a license from the board of dental examiners shall, within thirty days from the time of receiving the same, cause it to be recorded in the office of the Secretary of State, who shall be entitled to twenty-five cents for recording each license.

Sec. 9. A person who does not cause his license to be recorded within the time required by the preceding section shall forfeit the license, and shall not be relicensed until he has paid to the board the sum of ten dollars.

Sec. 10. This act shall take effect from its passage, except Section 6, which shall take effect on the first day of January, 1883.

Approved November 29, 1882.

VIRGINIA.—The following is the text of an act to regulate the practice of dentistry in the State of Virginia, which was approved February 26, 1886:

1. Be it enacted by the General Assembly of Virginia: That from and after the passage of this act it shall be unlawful for any person, except regularly authorized physicians and surgeons, to engage in the practice of dentistry in the Commonwealth of Virginia, or to receive license from any commissioner of the revenue, unless such person has graduated and received a diploma from the faculty of a reputable institution where this specialty is taught, and chartered under the authority of some one of the United States, or of a foreign government, acknowledged as such, or shall have obtained a certificate from a board of examiners duly appointed and authorized by the provisions of this act to issue such certificates; *provided*, That nothing herein contained shall prevent any person from extracting teeth for any one suffering from toothache.

2. That the board of examiners shall consist of six practitioners of dentistry who are of acknowledged ability in the profession. Said board shall be appointed by the governor, who shall select from twelve candidates named by the Virginia State Dental Association at their next annual meeting, of whom two shall serve one year, two for two years, and two for three years, and to reside in different sections of the State; and each year thereafter two shall be appointed in the same manner from four nominees, to serve for three years or until their successors are elected. All vacancies

for unexpired terms shall be filled by the governor from names furnished him by the board.

3. That it shall be the duty of this board—First, to meet annually at the time and place of meeting of the Virginia State Dental Association, and at such other time and place as the said board shall agree upon, to conduct the examination of applicants. They shall also meet for the same purpose, at the call of any four members of said board, at such time and place as may be designated. Thirty days' notice must be given of the meetings by advertising in at least two of the daily papers published in the Commonwealth of Virginia. Second, to grant a certificate of ability to practise dentistry, which certificate shall be signed by said board and stamped with a suitable seal, to all applicants who undergo a satisfactory examination and who received at least four affirmative votes. Third, to keep a book in which shall be registered the names and qualifications, as far as practicable, of all persons who have been granted certificates of ability to practise dentistry under the provisions of this act.

4. That the book so kept shall be a book of record, and transcripts from it, certified to by the officer who has it in keeping, with the seal of said board of examiners, shall be evidence in any court of this Commonwealth.

5. That four members of this board shall constitute a quorum for the transaction of business; and should a quorum not be present on any day appointed for their meeting, those present may adjourn from time to time until a quorum is present.

6. That any person who shall, in violation of this act, practise dentistry in the Commonwealth of Virginia shall be liable to indictment in the circuit, county, or corporation courts, and on conviction shall be fined not less than fifty nor more than two hundred dollars; *provided*, That any person so convicted shall not be entitled to any fee for services rendered; and if a fee shall have been paid, the patient or his or her heirs may recover the same as debts of like amount are now recovered by law.

7. That all fines collected shall inure to the public-school fund of the county or corporation in which the prosecution occurs.

8. That nothing in this act shall apply to persons who shall be engaged in the practice of dentistry in this Commonwealth at the time of or prior to the passage of this act.

9. To provide a fund to carry out the provisions of the third section of this act, it shall be the duty of said board of examiners to collect from those who shall appear before them for examination the sum of ten dollars each.

10. This act shall be in force from its passage.

WEST VIRGINIA.—*A Bill to Regulate the Practice of Dentistry in this State, and to Protect the People against Empiricism in Relation thereto.*

Be it enacted by the Legislature of West Virginia:

Section 1. That after the passage of this act it shall be unlawful for any person to engage in the practice of dentistry for compensation in this State unless such person shall have received a diploma from some dental college duly incorporated under the laws of this State or some one of the United States or foreign government, in which is annually delivered in good faith a full course of lectures and instruction in dentistry, or shall have obtained a license from a board of dentists duly authorized and appointed by the authorities of this or some one of the United States in the manner hereinafter mentioned.

Sec. 2. It shall be the duty of the board of public works to appoint nine dentists learned in the profession, three of whom shall be appointed in each Congressional district, who shall constitute a board for the examination of applicants in their own district, and before which any applicant for license to practise dentistry shall appear and be examined touching his proficiency in said art or profession; and if two or more of said board shall deem the said applicant qualified to practise said profession, they shall sign said license, for making which examination the said examiners shall have a fee of two dollars each, to be paid by the applicant. But before said application for a license shall be made to said examiners or signed by them the applicant shall produce to said examiners a certificate from the county court of some county that he has resided in said county for twelve months next preceding the date of such certificate, and that he is a person of good moral character; *provided*, That nothing in this act shall prevent any person from extracting teeth, or in any manner interfere with any person now engaged in the practice of dentistry in this State. The term of office of such board shall be five years.

Sec. 3. Any person violating the provisions of this act shall be deemed guilty of a misdemeanor, and on conviction thereof shall be fined not less than ten or more than one hundred dollars.

WISCONSIN.—The following is the text of an "Act to regulate the practice of dentistry and to establish a State board of dental examiners" in the State of Wisconsin:

The people of the State of Wisconsin, represented in Senate and Assembly, do enact as follows:

Section 1. It shall be unlawful for any person who is not, at the time of the passage of this act, engaged in the practice of dentistry in this State to commence such practice unless he shall have obtained a license as hereinafter provided.

Sec. 2. A board of examiners, to consist of five practising dentists, is hereby created, whose duty it shall be to carry out the purposes and enforce the provisions of this act. The members of said board shall be appointed by the governor. Three members of this board at least shall be members of the Wisconsin State Dental Society. The terms for which the members of said board shall hold their offices shall be five years, except that the members of the board first to be appointed under this act shall hold their offices for the terms of one, two, three, four, and five years respectively, and until their successors are appointed and qualified. In case of vacancy occurring in said board such vacancy shall be filled by the governor.

Sec. 3. Said board shall choose one of its members president and one secretary thereof, and it shall meet at least once in each year, and as much oftener and at such times and places as it may deem necessary. A majority of said board shall at all meetings constitute a quorum, and the proceedings thereof shall at all reasonable times be open to public inspection.

Sec. 4. It shall be the duty of every person who is engaged in the practice of dentistry in this State, within six months from the date of the passage of this act and annually thereafter, to cause his or her name and residence or place of business to be registered with said board of examiners, who shall keep a book for that purpose; and every person who shall register with said board as a practitioner of dentistry may continue to practise the same as such without incurring any of the liabilities or penalties pro-

vided in this act. The board of examiners shall furnish to the county clerks a certified list of those registered, and it shall be the duty of the county clerks to register such names in a book kept for such purpose. Every person registering with the board of examiners shall pay as a fee therefor the sum of one dollar.

Sec. 5. Any and all persons who shall so desire may appear before said board at any of its regular meetings and be examined with reference to their knowledge and skill in dental surgery; and if the examination of any such person or persons shall prove satisfactory to said board, the board of examiners shall issue to such persons as they shall find from such examination to possess the requisite qualifications a license to practise dentistry in accordance with the provisions of this act. But said board shall at all times issue a license to any regular graduate of any reputable legally-incorporated dental college which requires that the candidate for graduation shall attend two full courses of lectures of five months each, the last of which shall be attended in the institution granting the diploma, without examination, upon the payment by such graduate to the said board of a fee of one dollar. All licenses issued by said board shall be signed by the members thereof, and be attested by its president and secretary; and such license shall be *primâ-facie* evidence of the rights of the holder to practise dentistry in the State of Wisconsin.

Sec. 6. Any person who shall violate any of the provisions of this act shall be liable to prosecution before any court of competent jurisdiction upon information or by indictment, and upon conviction may be fined not less than fifty dollars nor more than two hundred dollars for each and every offence.

Sec. 7. In order to provide the means for carrying out and maintaining the provisions of this act, the said board of examiners may charge each person applying to or appearing before them for examination for license to practise dentistry a fee of ten dollars; and out of the funds coming into their possession from the fees mentioned in this act the members of said board may receive all legitimate and necessary expenses incurred in attending the meetings of said board and in conducting the business thereof. Said expenses shall be paid from the fees received by the board under the provisions of this act, and no part of the expenses of said board shall be paid out of the State treasury. All moneys received in excess of said expenses above provided for shall be held by the secretary of said board as a special fund for meeting the expenses of said board, he giving such bond as the board shall from time to time direct. And said board shall make an annual report of its proceedings to the governor on the thirtieth day of September in each year, together with an account of all moneys received and disbursed by them pursuant to this act.

Sec. 8. This act shall take effect and be in force from and after its passage and publication.

Approved March 23, 1885.

APPENDIX.

ALABAMA.—*An Act to Regulate the Practice of Dentistry in the State of Alabama,* as amended and approved February 28, 1887:

Section 1. Be it enacted by the General Assembly of Alabama, That from and after the passage of this act it shall be unlawful for any person to engage in the practice of dentistry in the State of Alabama, unless said person has obtained license from a board of dental examiners duly authorized and appointed by this act to issue such license; *provided,* That dentists who have been in the regular practice of dentistry for five years next preceding the passage of this act shall not be required to submit to an examination, and shall be entitled to license without fee, which shall be transmitted to him by mail or otherwise upon his application, accompanied by an affidavit to the fact of his having been in the practice for the required time.

Sec. 2. Be it further enacted, That the board of dental examiners shall consist of five (5) dental graduates, or practitioners of dentistry, who have obtained a license to practise dentistry from a dental board organized under this act, and who are members in good standing of the Alabama Dental Association; *provided,* That said graduates or practitioners have been practising dentistry in the State of Alabama for a period not less than three (3) years.

Sec. 3. Be it further enacted, That it shall be the duty of said Alabama Dental Association, at its annual meeting in April, 1887, to elect said Board of Dental Examiners, whose terms of office shall be respectively five, four, three, two, and one year, in the order in which they are elected; and at each annual meeting of said association thereafter one member shall be elected to fill such vacancy, who shall serve for the period of five years. The president shall have power to fill all vacancies in said board for unexpired terms.

Sec. 4. Be it further enacted, That it shall be the duty of said board of examiners—

1st. To meet annually at the time and place of meeting of the Alabama Dental Association, or oftener, at the call of any three members of the board. Thirty days' notice must be given of the time and place of meeting of said board, said notice to be mailed to all practising dentists in the State.

2d. To prescribe a course of reading for those who study dentistry under private instruction.

3d. To grant license to all applicants who undergo a satisfactory examination, who shall pay to the said board a fee of five dollars for said license.

4th. To keep a book in which shall be registered the names of all persons licensed to practise dentistry in this State.

Sec. 5. Be it further enacted, That the book so kept shall be a book of

record, and a transcript from it certified to by the officer who has it in keeping, with the common seal of said board, shall be evidence in any court of this State.

Sec. 6. Be it further enacted, That three members of said board shall constitute a quorum for the transaction of business, and should a quorum not be present on the day appointed for its meeting, those present may adjourn from day to day until a quorum is present.

Sec. 7. Be it further enacted, That one member of said board may grant a license for an application to practise until the next regular meeting of the board, when he shall report the fact, at which time the temporary license shall expire; but such temporary license shall not be granted by a member of the board after the board has rejected the applicant.

Sec. 8. Be it further enacted, That any person who shall, in violation of this act, practise dentistry in this State, shall be liable to indictment, and on conviction shall be fined not less than fifty nor more than three hundred dollars; *provided*, That nothing in this act shall be construed to prevent persons from extracting teeth; *provided*, That nothing in this act shall be so construed as to require any person who is now lawfully engaged in the practice of dentistry to procure any additional license or to attend any meeting or meetings of the State Dental Association.

Sec. 9. Be it further enacted, That on the trial of such indictment it shall be incumbent upon the defendant, to exempt him from the penalties of this act, to show that he has authority under the law to practise dentistry in this State.

Sec. 10. Be it further enacted, That every person to whom license is issued by said board of examiners shall, within thirty days from date thereof, present the same to the judge of the probate court of the county in which he resides, who shall officially indorse said license and seal it with the seal of the court, and who shall record said license in a book in his office, and who shall be entitled to a fee of one (1) dollar for his services; but a temporary license issued under Section 7 of this act need not be sealed or recorded.

Sec. 11. Be it further enacted, That it shall be the duty of the solicitors of this State to prosecute all persons violating all or any portion of this act.

Sec. 12. Be it further enacted, That all laws or parts of laws in conflict with this act be and the same are hereby repealed.

ARKANSAS.—*An Act to Regulate the Practice of Dentistry, and Punish Violators thereof, in the State of Arkansas.*

Be it enacted by the State of Arkansas:

Section 1. That it shall be unlawful for any person to practise, or to attempt to practise, dentistry or dental surgery in the State of Arkansas without first having received a certificate from the Board of Dental Examiners.

Sec. 2. A board of examiners, consisting of five practising dentists, residents of this State, is hereby created, who shall have authority to issue certificates to persons in the practice of dentistry or dental surgery in this State at the time of the passage of this act, and also to decide upon the validity of such diplomas as may be subsequently presented for registration, as hereinafter provided.

Sec. 3. The members of said board shall be appointed by the governor, and shall serve for a term of four years, excepting that the members of the board first appointed shall hold their offices as follows: Three for two,

and two for four years, respectively, and until their successors are duly appointed. In case of a vacancy occurring in said board, such vacancy shall be filled by appointment by the governor.

Sec. 4. Said board shall keep a record, in which shall be registered the names and residence or place of business of all persons authorized under this act to practise dentistry or dental surgery in this State. It shall elect one of its members president, and one secretary thereof, and it shall meet at least once in each year, and as much oftener and at such times and places as it may deem necessary. A majority of the members of said board shall constitute a quorum, and the proceedings thereof shall be at all times open for public inspection.

Sec. 5. Every person engaged in the practice of dentistry or dental surgery within this State at the time of the passage of this act shall, within three months thereafter, cause his or her name and residence and place of business to be registered with said board of examiners; upon which said board shall issue to such person a certificate, duly signed by a majority of the members of said board, and which certificate shall entitle the person to whom it is issued to all the rights and privileges set forth in Section 1 of this act.

Sec. 6. To provide for the proper and effective enforcement of this act, said board of examiners shall be entitled to the following fees—to wit: For each certificate issued to persons in practice in this State at the time of the passage of this act, the sum of one dollar; for each certificate issued to persons not engaged in the practice of dentistry in this State at the time of the passage of this act, the sum of five dollars.

Sec. 7. That members of said board shall each receive the compensation of two dollars and a half per day for each day actually engaged in the duties of their office, which, together with all other legitimate expenses incurred in the performance of such duties, shall be paid from fees received by the board under the provisions of this act; and no part of the expenses of said board shall at any time be paid out of the State treasury. All moneys in excess of said per-diem allowance and other expenses shall be held by the secretary of said board as a special fund for meeting the expenses of said board, he giving such bond as the board shall from time to time direct; and such board shall make an annual report of its proceedings to the governor by the fifteenth day of December of each year, together with an account of all moneys received and disbursed by them in pursuance of this act.

Sec. 8. Any person who shall violate this act by practising or attempting to practise dentistry within the State without first complying with the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined in any sum not less than ten dollars nor more than one hundred dollars, said fines to be applied to the school fund of the district in which the offence is committed.

Sec. 9. This act shall take effect and be in force from and after its publication.

Approved by the governor on the 2d of April, 1887.

CONNECTICUT.—*An Act to Regulate the Practice of Dentistry in the State of Connecticut.*

Be it enacted by the Senate and House of Representatives of the State of Connecticut in General Assembly convened:

Section 1. It shall be unlawful for any person who is not at the time of the passage of this act engaged in the practice of dentistry in this State

to commence such practice unless such person shall have received a diploma from the faculty of some dental college, duly authorized by the laws of this or some foreign country, in which college there was delivered annually, at the time said diploma was granted, a full course of lectures and instructions on dentistry, or shall have had eighteen months' pupilage in a dental office, and in addition thereto shall have attended one full course of lectures in some such college as specified above, or, in case of removal from another State or country, shall have received a certificate from some lawful board of dental examiners, or have had six years' regular dental practice; *provided*, That nothing in this act shall interfere with physicians in the discharge of their professional duties; and further *provided*, That this act shall not apply to any student studying or practising in the office of any dentist in this State.

Sec. 2. Any person who shall violate the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined not less than fifty nor more than two hundred dollars for each offence.

Approved by the governor on the 4th of April, 1887.

INDIANA.—The legislature of Indiana has recently passed a new act for the regulation of dentistry in that State. The new law, the text of which will be found below, went into effect the last Tuesday (28th) of June, 1887.

Section 1. Be it enacted by the General Assembly of the State of Indiana that it shall be unlawful for any one to practise dentistry in the State of Indiana at any time after thirty days from the appointment of the board of examiners provided for in Section 2 hereof, without being registered according to the provisions of this act.

Sec. 2. A board of examiners, consisting of five reputable practising dentists, shall be appointed on the last Tuesday of June, 1887, and biennially thereafter, one by the governor, one by the State Board of Health, and three by the Indiana State Dental Association, said board to serve for the term of two years from the date of such appointment; and it shall be the duty of said board to meet annually, at the time and place fixed for the meeting of said Dental Association, or oftener at the call of any three members of said board at such time and place as may be designated in such call. When convened the said board shall examine all applications, issue registration certificates thereon, and also examine all applicants for certificates of qualification, and issue such certificates to all such applicants as shall pass a satisfactory examination.

Sec. 3. Any person who shall prove to the satisfaction of said board of examiners that he is a graduate of a dental college duly and legally incorporated, and who shall present a diploma therefrom, and shall further show that said college is of good repute, shall be entitled to a registration certificate on the payment of a fee of one dollar to said board.

Sec. 4. Any person who shall present to the said board of examiners a valid certificate of qualification, issued by the board of examiners under the provisions of any former law of this State, shall be entitled to a certificate of registration upon the payment of a fee of one dollar to said board.

Sec. 5. Any person who shall file before said board of examiners an application under oath and sworn to by one or more freeholders, setting forth the fact that said applicant has been engaged in the lawful practice of dentistry in this State continuously since the 29th day of May, 1879,

shall be entitled to a registration certificate on the payment of a fee of one dollar to said board.

Sec. 6. Any person who shall desire to obtain a certificate of qualification to practise dentistry in the State, and who shall not be entitled to a registration certificate under any of the provisions of the preceding sections of the act, shall be by said board examined in anatomy, physiology, pathology, therapeutics, chemistry, and the theory and practice of surgical and mechanical dentistry, upon the payment of a fee of five dollars to said board; and should such examination of said applicant prove satisfactory to said board, it shall issue to said applicant a certificate of qualification and registration.

Sec. 7. Any member of the said board of examiners may grant a permit to practise dentistry to any person who shall file with said member his application therefor, but such permit shall only be valid until the next meeting of said board.

Sec. 8. All certificates (except permits) issued under this act shall be signed by at least three members of said board of examiners, and said certificate shall have the seal of the Indiana State Dental Association affixed thereto. A majority of said board shall constitute a quorum to transact business.

Sec. 9. All persons receiving certificates of registration from said board of examiners, or permits from any member thereof, before beginning to practise dentistry shall present said certificate of registration or permit to the recorder of the county wherein said applicant desires to practise, and the said recorder shall record said certificate or permit in the miscellaneous record of his office; and said recorder shall indorse the recording of the same on the applicant's certificate or permit, and for his service he shall collect from each applicant the sum of twenty-five cents.

Sec. 10. Any person who shall violate any of the provisions of this act shall, upon conviction thereof, be fined not less than twenty nor more than one hundred dollars for each offence; *provided*, That nothing in this act shall be construed to prevent any lawfully registered surgeon or physician from extracting teeth or performing any surgical operation in the line of his professional duties.

Sec. 11. The board shall receive out of the fund created by this act such compensation for their services as the by-laws of said State Dental Association may provide.

Sec. 12. An act entitled "An Act to Regulate the Practice of Dentistry," approved March 29, 1879, and printed in the Revised Statutes of 1881 as chapter 47, and being sections 4249 to 4257 inclusive, be and the same is hereby repealed, together with all laws in conflict with this act; *provided, however*, That all violation of the law hereby repealed may be prosecuted under the provisions of the laws in force at the time when such offence was committed.

MASSACHUSETTS.—*An Act to Establish a Board of Registration in Dentistry for the Commonwealth of Massachusetts.*

Be it enacted by the Senate and House of Representatives in General Court assembled, and by the authority of the same, as follows:

Section 1. The governor of the Commonwealth, with the advice and consent of the Council, shall appoint, after the passage of this act, five skilled dentists of good repute, residing and doing business within the Commonwealth, who shall constitute a board of registration in dentistry; but no person shall be eligible to serve on said board unless he or she shall

have been regularly graduated from some reputable medical or dental college duly authorized to grant degrees in dentistry, or shall have been engaged in the practice of dentistry for a period of not less than ten years previous to his appointment; *provided, however*, That no person shall be eligible to serve on said board who is in any way pecuniarily connected with any dental college or dental department of any college or university. The term for which the members of said board shall hold their office shall be three years, except that two of the members of the board, first to be appointed under this act, shall hold their office for the term of one year, two for the term of two years, and one for the term of three years, respectively, and until their successors shall be duly appointed and qualified. In case of a vacancy occurring in said board, such vacancy shall be filled by the governor in conformity with this section. Any member of said board may be removed from office for cause, by the governor, with the advice and consent of the Council.

Sec. 2. Said board shall choose one of its members president, and one secretary thereof, and it shall meet at least twice in each year. Four of said board shall constitute a quorum, and the proceedings thereof shall, at all reasonable times, be open to public inspection.

Sec. 3. Within six months from the time this act takes effect it shall be the duty of every person who is at that time engaged in the practice of dentistry in this State to cause his or her name, residence, and place of business to be registered with said board, which shall keep a book for that purpose. The statements of every such person shall be verified under oath before a notary public or justice of the peace in such manner as may be prescribed by the board. Every person engaged in the practice of dentistry within this Commonwealth at the time of the passage of this act, and who shall so register with said board as a practitioner of dentistry, shall receive a certificate to that effect, and may continue to practise without incurring any of the liabilities or penalties provided in this act.

Sec. 4. All persons not provided for in Section 3 may appear before said board at any of its regular meetings and be examined, either orally or by written examination, at the option of the several applicants, with reference to their knowledge and skill in dentistry and dental surgery; and if the examination of any such person or persons shall prove satisfactory to said board, the board shall issue to such person as it finds to possess the requisite qualifications a certificate to that effect, in accordance with the provisions of this act. All certificates issued by said board shall be signed by its officers, and such certificate shall be *primâ facie* evidence of the right of the holder to practise dentistry in Massachusetts.

Sec. 5. Any person who shall violate any of the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction may be fined not less than fifty nor more than one hundred dollars, or confined three months in the county jail, for each and every offence.

Sec. 6. The said board shall charge each person receiving a certificate the sum of fifty cents, and each person appearing before them for examination for a certificate of qualification a fee of ten dollars, which fee shall in no case be returned. Any person failing to pass a satisfactory examination shall be entitled to be re-examined at any future meeting of the board free of charge, but no applicant shall be examined oftener than twice in one year. Said board shall make an annual report of its proceedings to the governor by the thirty-first day of December in each year. All fees received by the board under this act shall be paid by the secretary of the board into the treasury of the Commonwealth once in each month.

Sec. 7. The compensation and all necessary expenses of the board shall be paid from the treasury of the Commonwealth. The compensation of the board shall be five dollars each for every day actually spent in the discharge of their duties, and three cents per mile each way for necessary travelling expenses in attending the meetings of the board, but in no case shall any more be paid than was actually expended. Such compensation and expenses shall be approved by the board and sent to the auditor of the Commonwealth, who shall certify to the governor and Council the amounts due, as in case of all other bills and accounts approved by him under the provisions of law; *provided*, That the amount so paid shall not exceed the amount received by the treasurer and receiver-general of the Commonwealth from the board in fees as herein specified, and so much of said receipts as may be necessary is hereby appropriated for the compensation and expenses as aforesaid.

Sec. 8. Any person who shall falsely claim or pretend to have or hold a certificate of license, granted by any board organized under and pursuant to the provisions of this act, or who shall falsely and with intent to deceive the public claim or pretend to be a graduate from any incorporated dental college, or who shall practise dentistry without obtaining a certificate as provided in this act, shall be deemed guilty of a misdemeanor, and shall be liable to the same penalty as provided in Section 5.

Sec. 9. Nothing in this act shall apply to any practising physician who is a graduate from the medical department of any incorporated college.

Sec. 10. This act shall take effect upon its passage.

Approved by the governor April 1, 1887.

NEBRASKA.—*An Act to Regulate the Practice of Dentistry, and Punish Violation thereof, in the State of Nebraska.*

Be it enacted by the Legislature of the State of Nebraska:

Section 1. It shall be unlawful for any persons to practise dentistry or dental surgery in the State of Nebraska without first having received a diploma from a reputable dental college or university duly incorporated or established under the laws of some one of the United States or some foreign government; *provided*, That nothing in Section 1 of this article shall apply to any *bonâ fide* practitioner of dentistry or dental surgery in this State at the time of the passage of this act; *and provided*, That nothing in this act shall be so construed as to prevent physicians or surgeons from extracting teeth.

Sec. 2. Every person who shall hereafter engage in the practice of dentistry or dental surgery in this State shall file a copy of his or her diploma with the county clerk of the county in which he or she resides, which copy shall be sworn to by the party filing the same; and the clerk shall give certificate of such fact, with the seal of the county attached thereto, to such party filing the copy of his or her diploma, and shall file and register the name of the person, the date of the filing, and the nature of the instrument in a book to be kept by him for that purpose, and as a compensation for his services the said clerk for filing and registering the same shall receive a fee of one dollar, to be paid by the person filing the diploma.

Sec. 3. Every *bonâ fide* practitioner of dentistry or dental surgery residing in this State at the time of the passage of this act, and desiring to continue the same, shall within ninety days after the passage of this act file an affidavit of said facts as to the length of time he or she has practised in this State with the county clerk of the county in which he or she resides;

and the said clerk shall register the name of, and give a certificate to, the party filing the affidavit, in like manner and of like effect as hereinbefore provided, and for such service shall receive a fee of one dollar, to be paid by the party filing the affidavit.

Sec. 4. All certificates issued under the provisions of this act shall be *primâ facie* evidence of the right of the holder to practise under this act.

Sec. 5. Every person violating the provisions of this act shall, upon conviction thereof, be deemed guilty of misdemeanor, and be punished by a fine of not less than fifty dollars; nor more than two hundred dollars, for each and every offence, or be imprisoned in the county jail for sixty days, or both fine and imprisonment at the discretion of the court; and all fines collected shall belong to and be paid into the common-school funds of the county where the offence was committed.

Sec. 6. Any person who shall have filed his or her affidavit or diploma, as required in Sections 2 and 3 of this act, in one county and remove to another county, shall, before entering upon the practice of his or her profession in such last-named county, procure a certified copy of the record of his or her former registry, and cause such transcript to be filed and recorded in the dental register of such county in which he or she has removed.

Approved by the governor March 23, 1887.

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Incorporated Glasgow Dental Hospital and School

211 Renfrew Street

Glasgow, C.3

GLASGOW DENTAL STUDENTS WAR MEMORIAL LIBRARY

RULES

1. The Library shall be a lending library.

2. The Library shall be for the use of students attending the Incorporated Glasgow Dental Hospital, and shall be free, except for students who have finished their curriculum, and are taking extra terms.

3. Extra term students who have finished their curriculum at the Hospital shall deposit one guinea for the use of the Library. Provided all books have been returned free from damage, the deposit shall be refunded.

4. Books on loan shall be returned within two weeks, but may be re-issued for a further similar period provided no other student has applied for them.

5. Only two volumes may be issued at one time.

6. The Library will be open on Thursdays between 3 o'clock and 7 o'clock for lending or exchanging books. The title of the book required should be handed in to the office, but books will only be given out on Thursdays.

7. All books lost or damaged must be replaced by the borrower.